# 2021-22 Wheat Science Research Report

College of Agriculture,
Food and Environment

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# EVALUATION OF ITALIAN RYEGRASS HERBICIDE RESISTANCE AND POTENTIAL UTILITY OF HARVEST WEED SEED CONTROL

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

## OBJECTIVES

Italian ryegrass (annual ryegrass) continues to be problematic in Kentucky wheat acres and has shown rapid increases in infestations over the past several growing seasons. This weed species has proved to be the most problematic weed for Kentucky wheat growers with our previous research identifying at least one population of glyphosate-resistant and one population of pinoxaden (Axial XL) resistant annual ryegrass in Kentucky wheat fields.

Since the identification of the single population of pinoxaden resistant ryegrass from Simpson County in 2017, we have observed numerous wheat fields through the state with late season ryegrass escapes. In addition to those escapes we have also received multiple complaints of failed glyphosate burndowns of this weed. The number of complaints of failed burndowns increased exponentially in 2021 and 2022.

Herbicide resistance in ryegrass is inevitable and Kentucky wheat acres are on the brink of widespread herbicide resistance. The lack of potential postemergence herbicides and limits of currently effective preemergence herbicides call for additional control tactics such as harvest weed seed control. Rigid ryegrass seed destruction at harvest has been implemented by Australian farmers for over a decade with much success. The investigation of the potential of this technology in Kentucky wheat acres is warranted at this time as Kentucky wheat farmer continue to struggle with annul ryegrass and herbicide resistance.

Objectives:

1. Conduct dose response studies on ryegrass populations that showed lack of control in initial greenhouse screenings
2. Investigate ryegrass seed retention, seed rain, and combine dispersal to further understand the utility of harvest weed seed control

## METHODS & MATERIALS

**Objective 1:** 22 populations of Italian ryegrass were screened against a susceptible population of ryegrass in 2020/21 using glyphosate, pinoxaden, and pinoxaden plus fenoxaprop. Three populations (Daviess 1, Pulaski 1, and Simpson 1) had significantly lower control using glyphosate and eight populations (Hickman 1, Simpson3, Simpson 4, Simpson 5, Simpson 6, Todd 1, Todd 2, and Todd 3) had significantly lower control with pinoxaden as compared to the susceptible population. The suspected populations were further screened under greenhouse conditions using dose response techniques against a susceptible population to further quantify potential herbicide resistance within the populations. The three dose response studies (glyphosate, pinoxaden, and pinoxaden plus fenoxaprop ) included rates from a 1/16 fold to a 16 fold rate of the labeled field rate. A complete list of rates and products can be found in Table 1. All trials were evaluated at 28 days after application and results subjected to a dose response analysis using the drm package in R.

**Objective 2:** Commercial grower wheat fields with ryegrass escapes were evaluated for annual ryegrass seed rain June of 2020 and 2021 prior to wheat harvest. A 1m$^2$ area was evaluated for every 0.5 acre of infestation within each field evaluated. Within the 1 m$^2$ area all ryegrass seed heads were collected and all debris on the soil surface immediately within the 1m$^2$ collected using a vacuum. Ryegrass seed was then separated and cleaned of all other debris within the samples. Ryegrass seed samples were weighed and counted to achieve a distribution of seed retained on the seed head and seed that had "rained" to the soil surface just prior to wheat harvest.

A field located at the University of Kentucky Research and Education Center was further evaluated for distribution of ryegrass during wheat harvest in 2020 and 2021. Samples were collected from below the combine header, from the chaff behind the combine, and from the combine grain tank. Four samples per 1 acre of infestation were collected during harvest in each year. Ryegrass seed was separated from all other debris, grain, and chaff within the collected samples. Ryegrass seed samples were weighed and counted to achieve a distribution of ryegrass seed that shattered at the combine header, seed contained within the chaff, and seed contained within the grain tank.

## RESULTS AND DISCUSSION

**Objective 1.** The dose response curves created based on visual control 28 days after glyphosate application revealed that two of the suspected populations had visually different curves than the susceptible populations (Figure 1). The Pulaski 1 and Simpson 1 populations required a significantly higher dose of glyphosate to reach 50% control as compared to the susceptible populations, while the Daviess 1 population was similar to the susceptible. These results confirm that at least two additional (in addition to populations confirmed in 2017) populations of Italian ryegrass are expressing glyphosate-resistance in Kentucky.

Dose response curves based on visual control 28 days after pinoxaden and pinoxaden plus fenoxaprop showed that at least three populations had different curves than the susceptible population (Figure 2 and 3, respectively). Todd 1, Todd 2, and Todd 3 all required significantly greater doses of pinoxaden and pinoxaden plus fenoxaprop to reach 50% control as compared to the susceptible population. While the Simpson 3, Simpson 4, Simpson 5, and Simpson 6 curve all visually look different than the susceptible, the doses of both pinoxaden and pinoxaden plus fenoxaprop to achieve 50% control were similar to the susceptible. The similarity in doses to achieve 50% control while appearing visually different is likely due to high variability in the response of the Simpson populations to each dose of pinoxaden and pinoxaden plus fenoxaprop. This indicates that while the four populations cannot be officially considered resistant, the populations are very likely in the beginning stages of resistance selection with a mixture of both susceptible and resistant plants existing across those field populations. While the three Todd populations can be confirmed resistant to pinoxaden and pinoxaden plus fenoxaprop with a high level of resistance occurring within each population.

**Objective 2.** Seed retention and rain collections were analyzed from eight locations collected in 2020 and 2021 from across 4 wheat growing counties in Kentucky. At all locations seed retention and rain collections were conduction within three days prior to the wheat field harvest operation. Across locations, the majority of seed was retained within the ryegrass seed head prior to harvest. The samples showed that a mean of 1069 Italian ryegrass seeds/ft$^2$ remained on the seed heads prior to wheat harvest as compared to 138 Italian ryegrass seeds/ft$^2$ found in the soil surface (Figure 4). This study conducted across eight site years indicates that Italian ryegrass will retain 89% of its seeds up to the time of soft red winter wheat harvest in Kentucky.

Italian ryegrass seed dispersal at harvest was evaluated in 2020 and 2021 at the UKREC location. Differences in Italian ryegrass seed distribution during the 2020 wheat harvest were not found with 660 seeds/ft$^2$ occurring within the chaff exiting the combine, 464 seeds/ft$^2$ within the grain tank, and 414 seeds seeds/ft$^2$ shattered at the combine header (Figure 5). In 2021, differences between the three collections did occur with 72 seeds/ft$^2$ passing through the combine with the chaff, 71 seeds/ft$^2$ occurring in the grain tank, and 6 seeds seeds/ft$^2$ shattering at the combine header (Figure 5). In 2021 the amount of Italian ryegrass seed that shattered at the combine header was significantly lower as compared to number of seed found in the chaff collection and the grain tank.

As the objective of this research was to observe the potential efficacy of harvest weed seed control, the Italian ryegrass seed entering into the combine versus seed shattering at the head was the primary focus. Therefore, the Italian ryegrass seed in the grain tank samples and the chaff collection were combined as both proportions had successfully entered the combine at harvest. Using this comparison 414 Italian ryegrass seeds/ft$^2$ shattered at the header and was significantly less than the 1123 Italian ryegrass seeds/ft$^2$ that entered the combine in 2020 (Figure 6). Similarly in 2021, 6 Italian ryegrass seeds/ft$^2$ shattered at the header and was significantly less as compared to the 142 Italian ryegrass seeds/ft$^2$ that entered the combine (Figure 6). When comparing the number of ryegrass seeds entering the combine versus seed shattering at the head or being deposited back into the soil seed bank, the results support the concept that harvest weed seed control may be a viable option for Italian ryegrass in Kentucky wheat.

## CONCLUSION

Dose response studies confirmed at least 2 additional glyphosate resistant and 3 pinoxaden (Axial XL) and pinoxaden plus fenoxaprop (Axial Bold) resistant populations of Italian ryegrass have been found in Kentucky. Additionally, several populations showed indications of early selection of pinoxaden and pinoxaden plus fenoxaprop resistance events are occurring within the populations. The resistant populations or populations showing early stages of resistance selection occurred in either Simpson or Todd Counties where a large proportion of wheat is grown in Kentucky and have historically dealt with ryegrass as a problematic weed species in this crop. Many growers within this region have relied heavily on pinoxaden based herbicides for postemergence control of ryegrass, and thus it is not surprising to find a high proportion of pinoxaden resistance occurring in this region. Looking toward the future, it should be assumed that pinoxaden resistance in ryegrass will continue to occur and spread in wheat growing regions of Kentucky.

The reality of inevitable widespread resistance to pinoxaden, calls for alternative practices to control ryegrass in wheat. One potential non-chemical control method is the use of harvest weed seed control at harvest. The successful use of harvest weed seed control depends on seed being retained on ryegrass seed heads prior to wheat harvest and being taken into harvest equipment and contained within the chaff of the crop that is distributed behind the combine. Results of this research show that at least 89% of ryegrass seed is retained on the seed head prior to harvest. Additionally, across two years 73 to 96% of ryegrass seed successfully entered the combine to be either deposited in the grain tank or exit with chaff for possible control with a harvest weed seed control tactic. The number of seed entering the combine was significantly greater both years as compared to the number of seed shattering at the combine head. These results indicate that Italian ryegrass in Kentucky wheat is a good candidate for harvest weed seed control and that it could be an additional tool for wheat growers dealing with herbicide resistant ryegrass. Additional research is ongoing to further evaluate the utility of both a seed control unit and chaff lining for control of Italian ryegrass in Kentucky.

## ACKNOWLEDGEMENTS

The author would like to thank the Kentucky Small Grain Growers Association and Siemer Milling for providing funding to support this research.

**Table 1. Rates of glyphosate (Roundup PowerMax 3), Pinoxaden (Axial XL), and Pinoxaden + Fenoxaprop (Axial Bold) evaluated in the dose response study.**

| | Glyphosate (g ae/ha) | Roundup PowerMax3 (fl oz/A) | Pinoxaden (g ai/ha) | Axial XL (fl oz/A) | Pinoxaden + Fenoxaprop (g ai/ha) | Axial Bold (fl oz/A) |
|---|---|---|---|---|---|---|
| **0x Rate** | 0 | 0 | 0 | 0 | 0 | 0 |
| **1/16th x Rate** | 58 | 1.25 | 4 | 1.025 | 4 + 2 | 0.9375 |
| **1/8th x Rate** | 105 | 2.5 | 8 | 2.05 | 7 + 4 | 1.875 |
| **1/4th x Rate** | 211 | 5 | 15 | 4.1 | 15 + 7 | 3.75 |
| **1/2x Rate** | 420 | 10 | 30 | 8.2 | 30 + 15 | 7.5 |
| **1x Rate** | 841 | 20 | 61 | 16.4 | 60 + 30 | 15 |
| **2x Rate** | 1681 | 40 | 121 | 32.8 | 120 + 59 | 30 |
| **4x Rate** | 3363 | 80 | 241 | 65.6 | 240 + 119 | 60 |
| **8x Rate** | 6725 | 160 | 482 | 131.2 | 480 + 237 | 120 |
| **16x Rate** | 13,450 | 320 | 964 | 262.4 | 960 + 479 | 240 |

**Figure 1. Dose response curves of 3 suspected glyphosate-resistant and one susceptible (SUS) Italian ryegrass population based on visual evaluations 28 days after glyphosate application.**

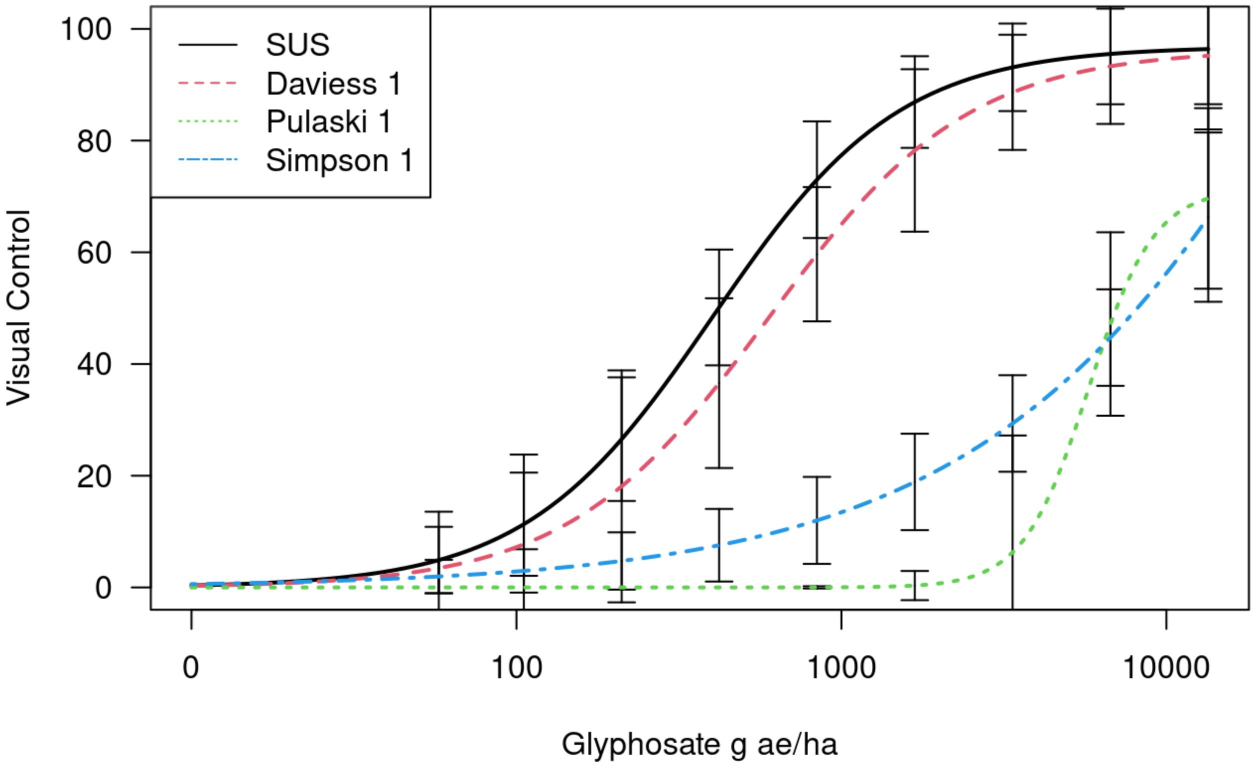


**Figure 2. Dose response curves of 8 suspected pinoxaden-resistant and one susceptible (SUS) Italian ryegrass populations based on visual evaluations 28 days after pinoxaden (Axial XL) application.**

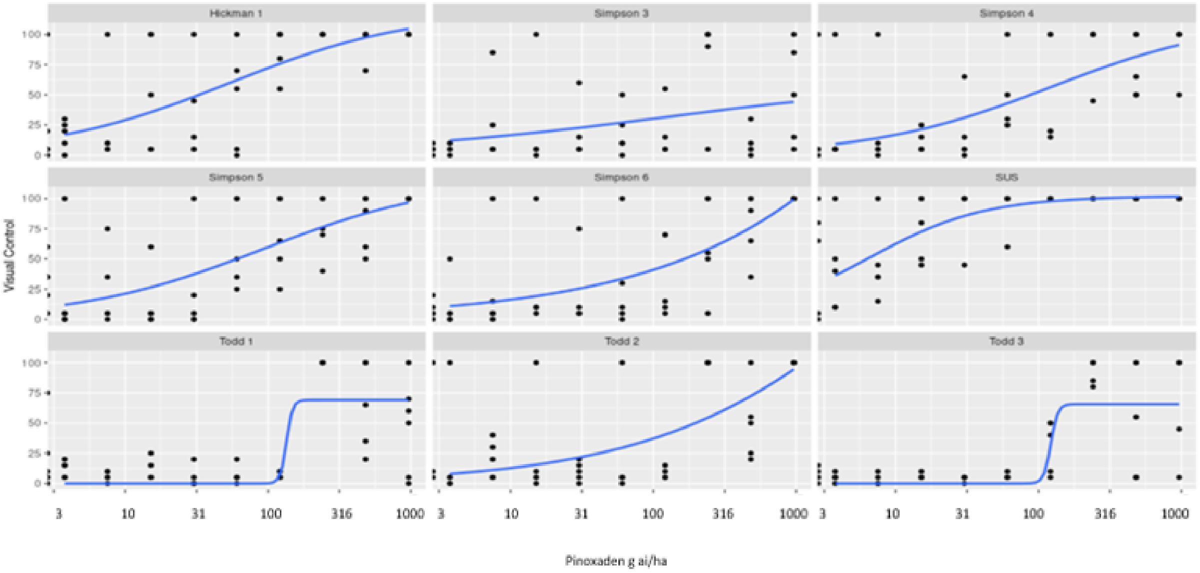


**Figure 3. Dose response curves of 8 suspected pinoxaden and fenoxaprop-resistant and one susceptible (SUS) Italian ryegrass population based on visual evaluations 28 days after pinoxaden plus fenoxaprop (Axial Bold) application.**

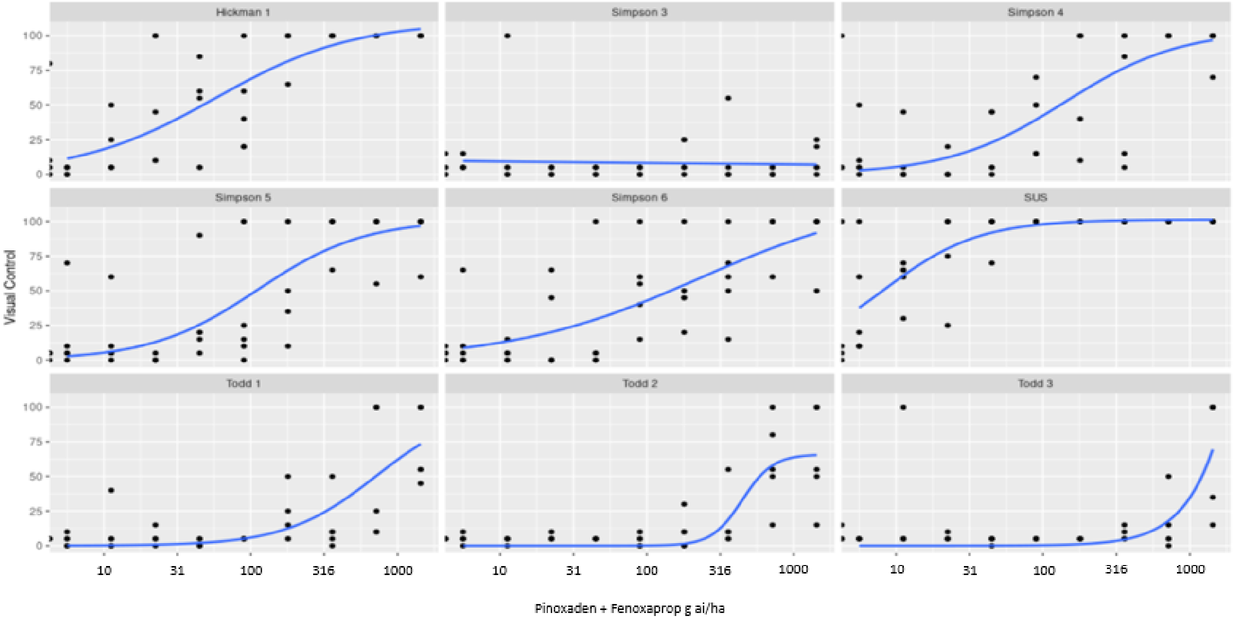
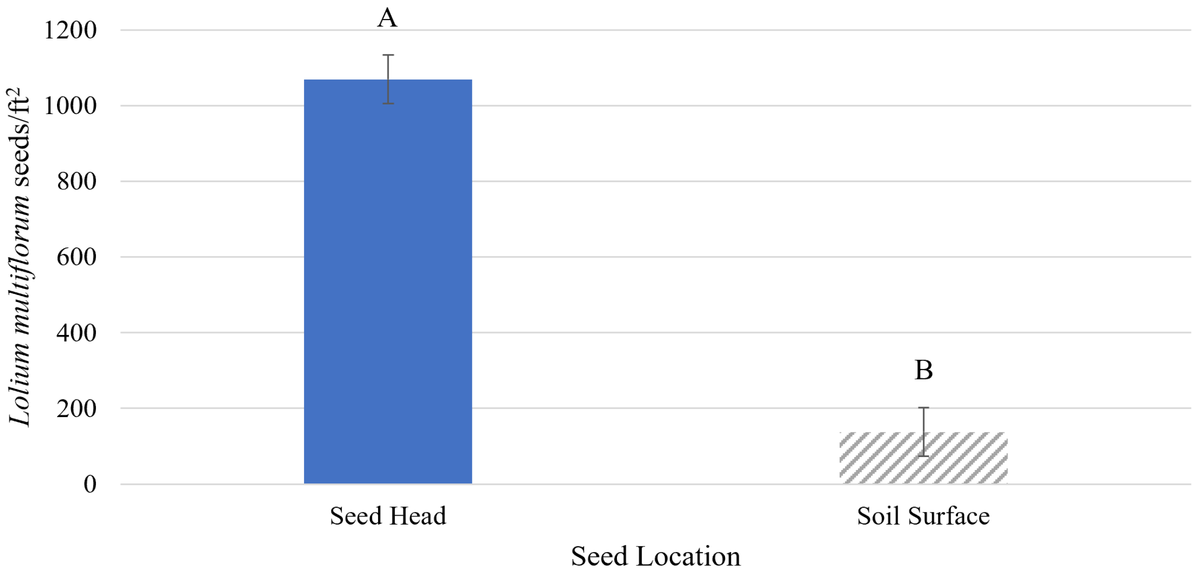
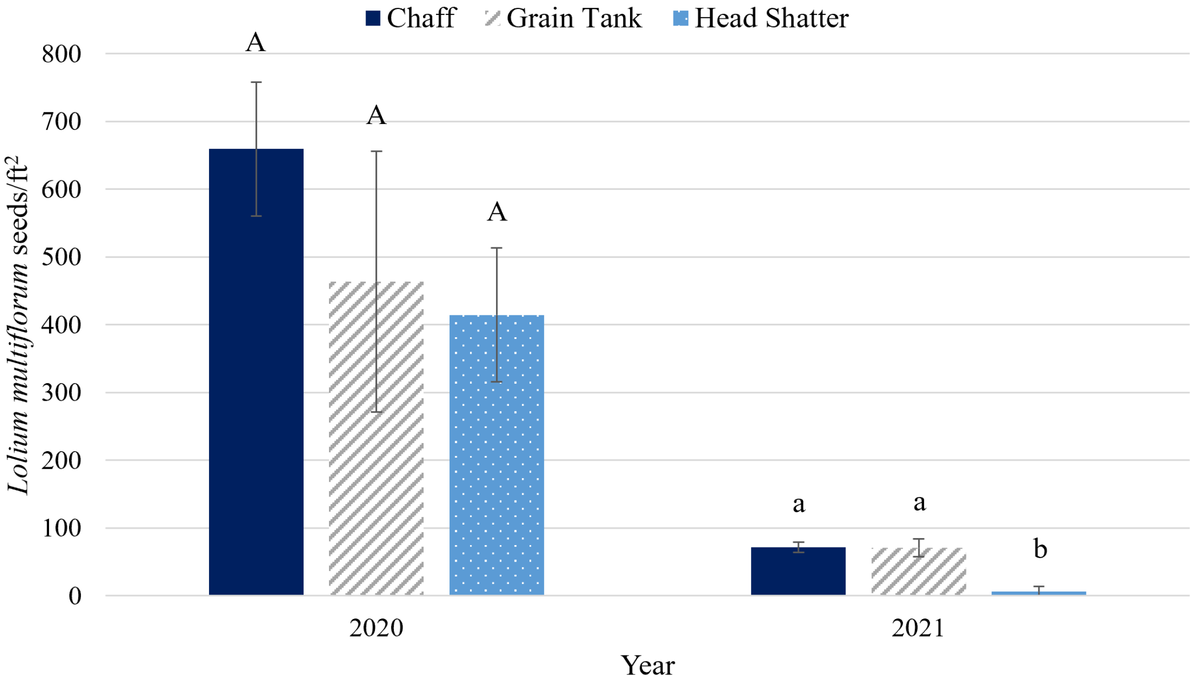


**Figure 4. Location of Italian ryegrass seed prior to Kentucky's soft red winter wheat harvest combined over eight sites in 2020 and 2021.**



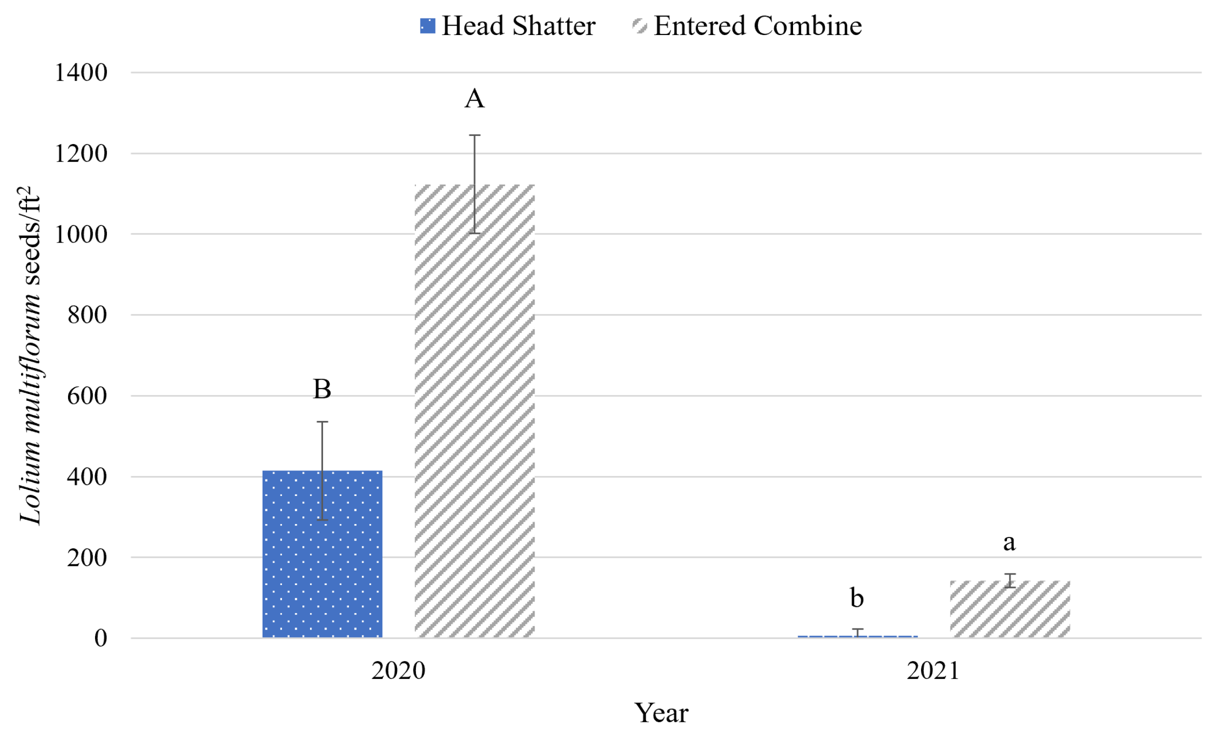
* Means followed a different letter are significantly different. Tukey HSD α=0.05

**Figure 5. Distribution of Italian ryegrass seed during harvest of soft red winter wheat in Kentucky in 2020 and 2021. Distribution points include ryegrass seed shattered at combine header, seed deposited in combine grain tank with wheat, and seed discharged from the combine with crop chaff.**



* Means within a year followed a different letter are significantly different. Tukey HSD α=0.05

**Figure 6. Distribution of Italian ryegrass seed during harvest of soft red winter wheat in Kentucky in 2020 and 2021. Distribution points include ryegrass seed shattered at combine header and seed that successfully entered the combine.**



* Means within a year followed a different letter are significantly different. Tukey HSD α=0.05

# WINTER COVER CROP EFFECTS ON SOIL HEALTH IN SLOPING CROPLAND

Hanna Poffenbarger, Lucas Pecci Canisares, Ole Wendorth, and Montse Salmeron
University of Kentucky, Lexington

## OBJECTIVE

Healthy soils are critical for high and stable productivity of wheat and other crops grown in Kentucky. Growing cover crops is one way to improve soil health. However, research findings about cover crop impacts on soil health and sustainability are derived mainly from flat research plots that are not representative of the rolling cropland that is common in Kentucky. These existing datasets may overlook the disproportionate benefits that cover crops can provide on sloping land. The objective of this study is to determine the effects of cereal rye and mixed cereal rye-crimson clover cover crops on soil organic matter and other soil health indicators at three different landscape positions. We expected to find that cover crops would have greater benefits for soil health on sloping land than flat land.

## METHODS & MATERIALS

We investigated winter cover crop effects on soil health using an existing field study at University of Kentucky's Spindletop Farm. The study includes two fields that rotate between corn and soybeans. The study was established in the first field 2018 and in the second field in 2019. Each field includes three landscape positions – top of hill (summit), side of hill (backslope), and bottom of hill (toeslope). At each of those positions, three winter cover crop treatments – cereal rye, cereal rye-crimson clover, and winter fallow were established. The project involves routine sampling for soil moisture, soil inorganic nitrogen (N), cover crop biomass and N uptake, corn N uptake, and crop yields. Cover crop biomass and crop yield data from this study are summarized in Table 1. On April 19, 2021 just before cover crop termination, we took soil samples at 0-10 and 10-20 cm (0-4 and 4-8 inches) in the first field. The samples were air-dried, sieved through a 2 mm screen, and analyzed for soil organic carbon (C), potential respiration, potential N mineralization, and wet aggregate stability. Soil organic C was measured using the dry combustion method. Potential respiration was measured using a soil incubation in which 100 g of air-dried soil were brought to 60% water-holding capacity and carbon dioxide concentrations were measured in the incubation jars after 0, 24, 48, and 72 hours of incubation. Potential N mineralization was measured using a soil incubation in which 8 g of air-dried soil were brought to 60% water-holding capacity and inorganic N was measured after 0 and 7 days of incubation. Wet aggregate stability was determined as the portion of 1-2 mm aggregates that remained on a 0.250 mm sieve following three minutes of oscillation in water. We repeated the sampling in spring of 2022 in the second field, but analysis of those samples is still in progress.

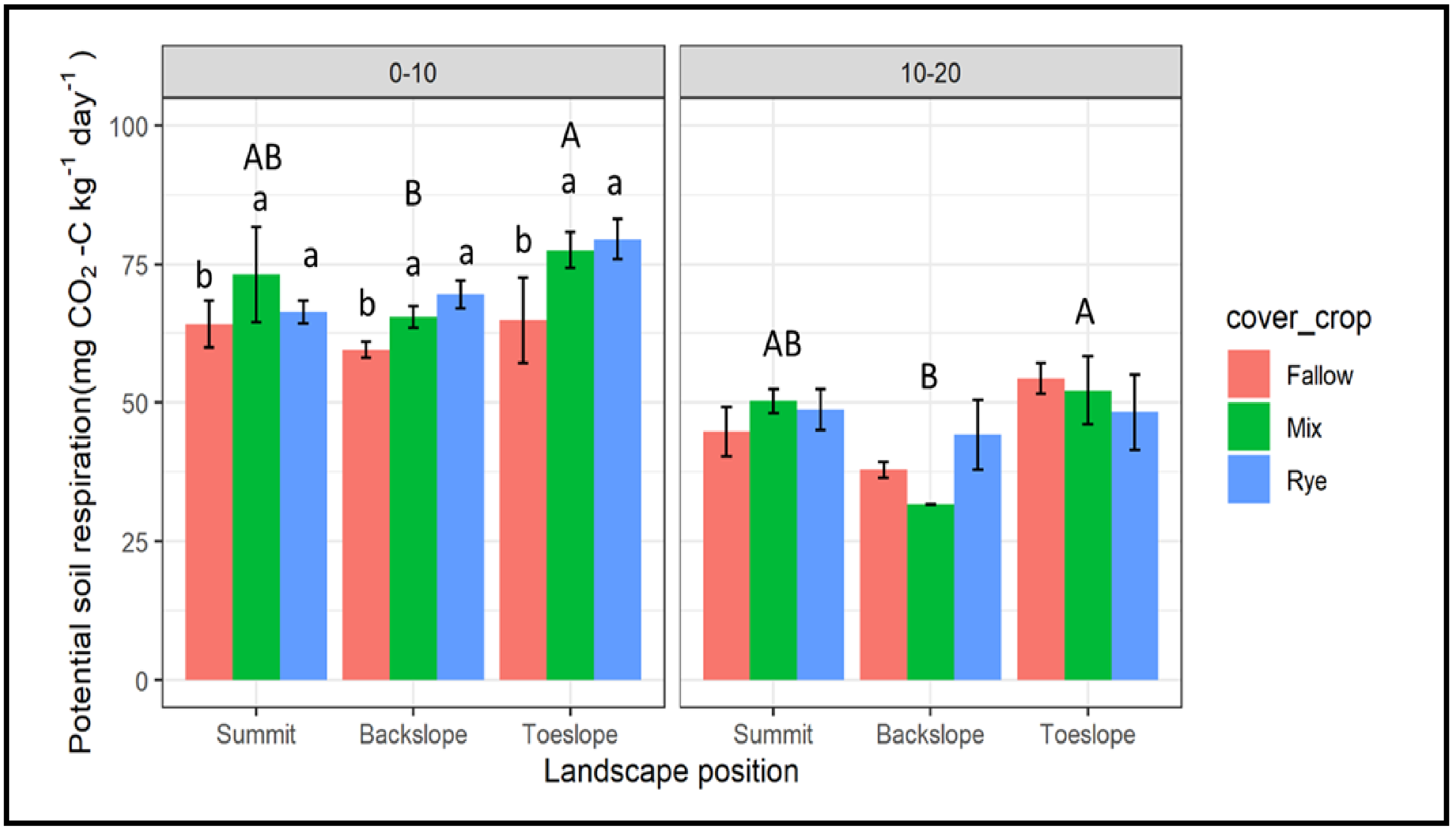


**Figure 2. Potential soil respiration for 0-10 cm (left) and 10-20 cm (right) by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. Different capital letters show differences among landscape positions averaged across cover crop treatments, while different lowercase letters show differences among cover crop treatments within each landscape position. There were no significant effects of cover crop treatment on potential soil respiration at 10-20 cm.**

Potential soil respiration is an indicator of microbial activity and fast-turnover soil organic matter. In the surface 0-10 cm, potential soil respiration was 15% greater on the toeslope than the backslope position, while the summit had an intermediate potential respiration rate. In addition, potential soil respiration was 15% greater with a mixture or rye cover crop than winter fallow. The effect of cover crop use was similar across landscape positions. The 10-20 cm had generally lower potential respiration than the 0-10 cm layer. While the toeslope maintained higher soil potential respiration than the backslope at 10-20 cm, there was no cover crop effect at that depth.

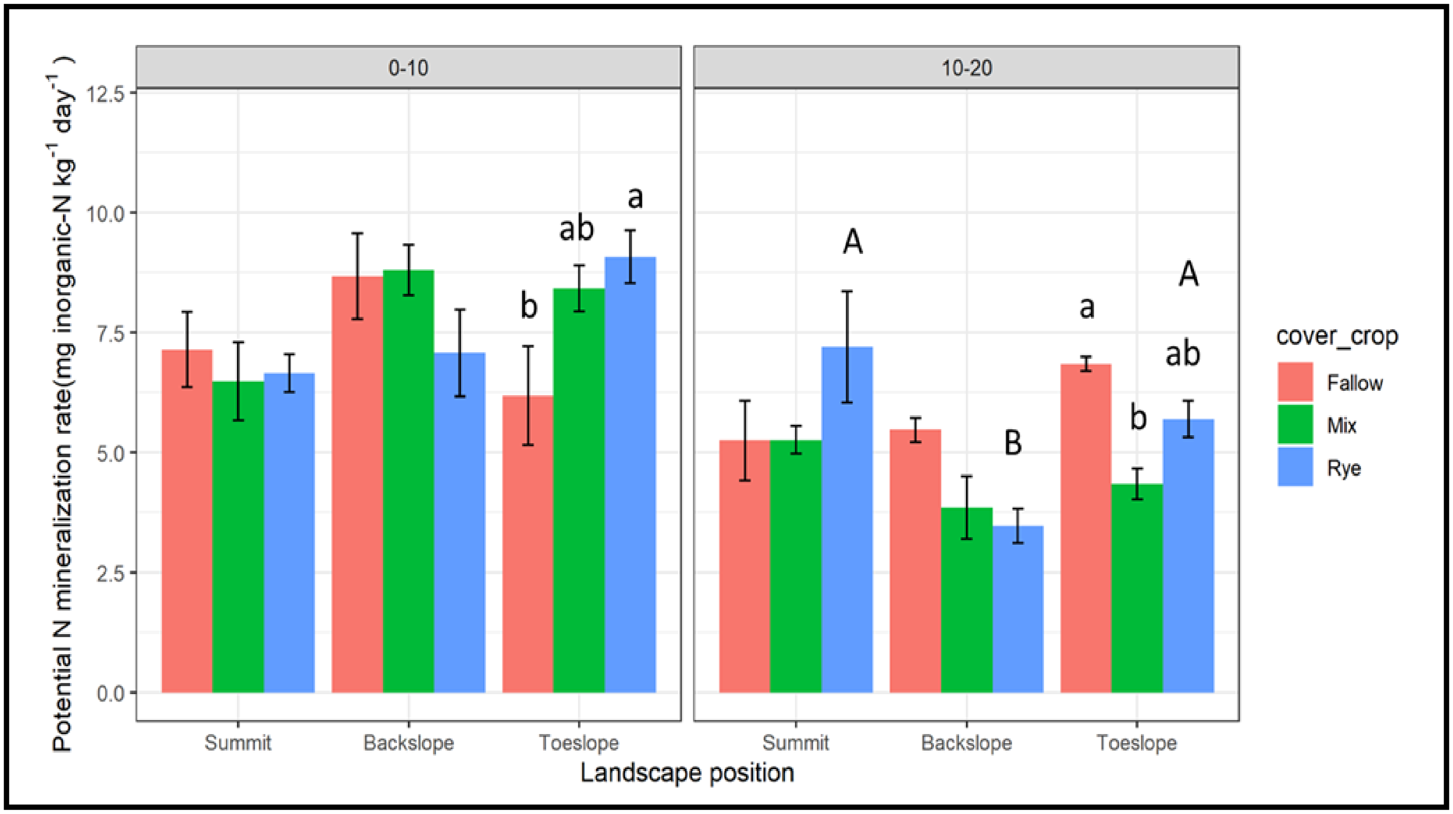


**Figure 3. Soil potential N mineralization for 0-10 cm (left) and 10-20 cm (right) by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. Different capital letters show differences among landscape positions for a particular cover crop treatment while different lowercase letters show differences among cover crop treatments within a particular landscape position. There was no effect of landscape position on potential N mineralization at 0-10 cm and no effect of cover crop treatment on the summit and backslope position at either depth.**

Potential N mineralization is an indicator of the soil's ability to supply plant-available N. In the surface 0-10 cm, potential N mineralization was greater with a rye cover crop than winter fallow on the toeslope position. However, the cover crop effect on the toeslope was reversed in the 10-20 cm depth, where the cover crop mixture led to significantly lower potential N mineralization than fallow. The rye cover crop increased variation in potential N mineralization among landscape positions at 10-20 cm, with significantly greater N mineralization on the summit and toeslope than on the backslope in the rye cover crop treatment.

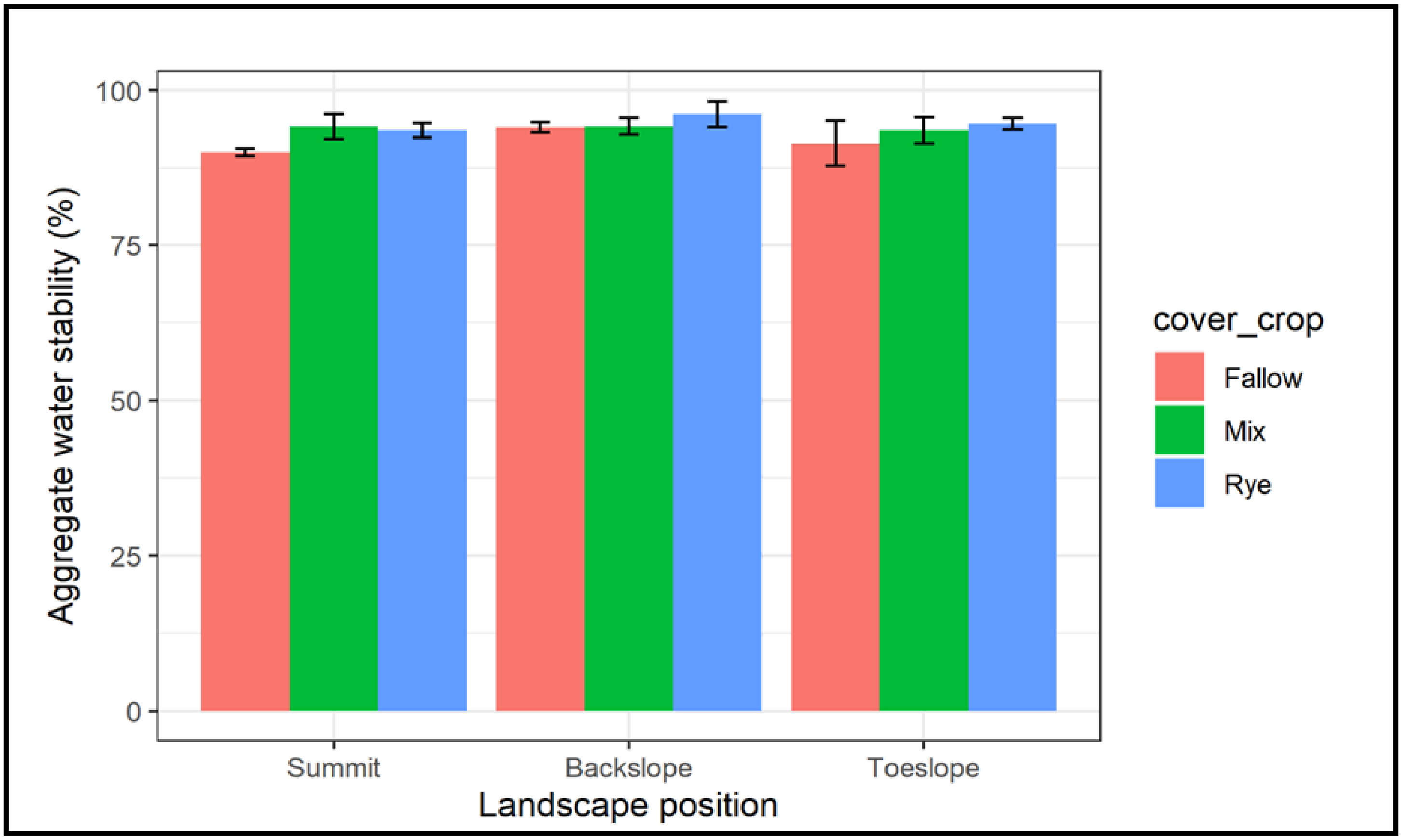


**Figure 4. Percentage water-stable aggregates for 0-10 cm by landscape position measured in spring 2021 following three years of cover crop treatments in a corn-soybean rotation. There were no significant effects of landscape position or cover crop treatment on percentage water-stable aggregates.**

Soil aggregate stability is an indicator of soil structure and tilth. We found all three landscape positions had very high percentages of water-stable aggregates, and the cover crop treatments tended to increase the aggregate stability, though the effect was not statistically significant. We are still in the process of measuring aggregate stability for the 10 -20 cm depth.

## DISCUSSION

The mixture and rye cover crops increased potential respiration in the top 10 cm across all landscape positions relative to the winter fallow treatment (Figure 2), suggesting that both cover crop treatments were effective in enhancing the fast-turnover, easily decomposable soil organic matter that is responsible for feeding the soil microbial community. The greater potential mineralization of the mixture and rye cover crop treatments may be an early indication of soil organic C buildup. Indeed, the soil organic C concentrations showed a similar trend in response to cover crop treatment as the potential respiration (Figure 1), though the effects were not statistically significant for soil organic C. Soil organic C often takes five years or more to show statistically significant changes, while potential respiration can change more quickly because it represents a fast-turnover fraction of soil organic matter. We observed that the backslope position had the lowest potential respiration despite having the highest soil organic C concentration (Figure 1). This demonstrates that the potential respiration reflects only the easily decomposable forms of organic matter, such as cash crop and cover crop residues. The backslope position is the least productive position in terms of crop yield and thus has the lowest crop residues and lowest potential respiration despite its high soil organic C concentration (Table 1). On the other hand, the toeslope is the highest yielding position and thus has the most crop residue inputs and potential respiration.

The easily decomposable organic matter is thought to contribute to nutrient release. However, the effect of cover crops on potential N mineralization was less consistent than their effect on potential respiration. The rye cover crop increased potential N mineralization in the top 10 cm on the toeslope, but the mixture cover crop decreased potential N mineralization in the 10-20 cm layer on the toeslope. In this study, the C:N ratio of aboveground cover crop biomass ranges from 25 to 35, meaning that the residues contain about as much N as the microbes need to decompose the residue. With a moderate C:N ratio, the cover crop residues are not expected to release N quickly. Since we sampled immediately after cover crop termination, it is possible that the cover crop residue had not decomposed enough to cause significant N mineralization. The C:N ratio of cover crop roots ranges from 35 to 60, and it is possible that the high abundance of roots at 10-20 cm depth led to N immobilization on the toeslope position with the cover crop mixture.

The easily decomposable organic matter is also thought to promote aggregate stabilization. However, we did not find that the cover crop treatments increased aggregate stability. The aggregate stability was quite high even in the no cover crop treatment, which suggests that the soils have favorable structure with minimal opportunity for improvement in this property.

## CONCLUSION

Our research suggests that cereal rye and cereal rye-crimson clover mixtures were equally effective in increasing soil potential respiration across landscape positions. The increased soil potential respiration is an early indication that the cover crops are contributing to buildup of soil organic C. We noted that potential respiration increased with crop yield among the landscape positions, suggesting that both cover crops and productive cash crops are beneficial for soil health. The cover crops had inconsistent effects on potential N mineralization and negligible effects on soil aggregate stability.

## ACKNOWLEDGEMENTS

We would like to thank the Kentucky Small Grain Growers' Association for their funding support of this project. Funding for the field study was also provided by United States Department of Agriculture National Institute of Food and Agriculture Grant Number 2020-67013-30860. We thank Kristine Gauthier for her help performing the soil health measurements and Laura Harris and Gene Hahn for their help with implementing the field study.

**Table 1. Average winter biomass production, corn yield, and soybean yield for field #1 of the landscape position project averaged across years. Corn received 240 lb N/acre. Winter biomass production for the fallow treatment was derived from winter weeds. Standard errors are shown in parentheses.**

| Cover crop | Summit | Backslope | Toeslope |
|---|---|---|---|
| Winter biomass, lb/acre (2019-2021) | | | |
| Fallow | 211 (63) | 440 (114) | 203 (156) |
| Mix | 4000 (544) | 3450 (353) | 3460 (750) |
| Rye | 3690 (349) | 3110 (266) | 3040 (377) |
| Corn yield, bu/acre (2019, 2021) | | | |
| Fallow | 211 (22) | 152 (19) | 239 (19) |
| Mix | 220 (25) | 136 (25) | 237 (16) |
| Rye | 201 (23) | 131 (19) | 212 (20) |
| Soybean yield, bu/acre (2020) | | | |
| Fallow | 54.8 (0.57) | 39.0 (2.28) | 61.1 (2.07) |
| Mix | 54.5 (1.02) | 38.1 (1.55) | 61.7 (0.57) |
| Rye | 52.2 (3.19) | 39.8 (1.22) | 59.1 (1.04) |

# WHEAT VARIETAL DIFFERENCES IN DISEASE REACTION

Bill Bruening
University of Kentucky, Lexington

## OBJECTIVE

Wheat variety selection is the simplest, most cost effective way to maximize production profitability. One component of production profitability is potential yield and seed quality reductions associated with disease. Selection of varieties with good levels of disease resistance is a sustainable practice and may eliminate the need for fungicide applications. Utilization of wheat variety disease rating data may also help growers determine if their wheat crop is susceptible to a particular pathogen that is present in the region and assist in the decision making process as to whether a fungicide may be needed or not.

## METHODS & MATERIALS

Eighty-three wheat varieties were rated for disease reaction at 2 Kentucky locations as part of the 2022 Kentucky Small Grain Variety Trials. The experimental design was a randomized complete block. The trials had four replications per entry, and the data presented are the average response from the four replications.

The plots were planted with specially built multi-row cone seeders in a conventionally tilled field. The trial plots consisted of six rows to form a plot 4 feet wide and 15 feet long, which was later trimmed to 12 feet in length. The preceding crop for both trials was corn.

Trials were conducted using intensive management practices. Herbicide (Harmony Extra) for broadleaf weed control was applied in the spring. Fungicides were intentionally not applied at these two locations to conduct disease ratings. Seeds were treated with a fungicide and systemic insecticide and an insecticide for aphid control was applied in the spring. Nitrogen was applied in a February/March split application at a rate of approximately 30/60 pounds per acre.

Disease ratings: Leaf rust, leaf blotch and head scab were rated at both the Fayette county and the Logan county trials. Powderly mildew, glume blotch and stripe rust were rated at the Fayette county trial. Rating scale (1-9) was used to indicate “1” having no infection or completely resistant and “9” indicating very high infection levels or extreme susceptibility.

## RESULTS AND DISCUSSION

Leaf Blotch Complex infection consisted primarily of *Septoria tritici* which causes brown, elongated rectangular lesions with irregular borders and to lesser extent *Stagonospora nodorum* which causes lens-shaped, tan-brown lesions of varying sizes with regular border. Damage results in reductions in yield and test weight. Management includes planting disease resistant varieties, using fungicide treated seed and applying a foliar fungicide after the flag leaf has emerged. 2022 Leaf Blotch ratings (Table 1) ranged from 2.6 to 8.4 and averaged 5.4.

Fusarium Head Blight (Head Scab) is caused by the pathogen *Fusarium graminearum* and causes spikelets to turn white or creamy on otherwise green heads (Image 1). Damage causes reductions in yield and test weight and grain vomitoxin accumulation. Management includes planting varieties with higher levels of resistance and the application of a recommended fungicide during early flowering. 2022 Head Scab ratings (Table 1) ranged from 1.5 to 7.6 and averaged 4.0.

Glume blotch is caused by the pathogen *Stagonospora nodorum* and causes glumes and awns to develop gray-brown blotches, usually starting at the tips of the glumes. Damage causes reductions in test weight and seed quality. Management includes planting moderately resistant varieties and foliar fungicides applied during early heading. 2022 Glume Blotch ratings (Table 1) ranged from 1.5 to 7.5 and averaged 3.0.

Powdery mildew is caused by the pathogen *Podosphaera xanthii* and causes white, powdery patches predominantly on leaves in the lower canopy, but can spread to the entire plant. Damage can result in reductions in yield and test weight. Management includes planting resistant varieties and using a foliar fungicide on susceptible varieties. Powdery Mildew ratings (Table 1) ranged from 1.0 to 8.5 and averaged 2.5.

Leaf Rust is caused by the pathogen *Puccinia triticina* and causes small rusty-orange pustules on the upper surface of leaves. Infection can results in reductions in yield and test weight. Management includes planting resistant varieties and using a foliar fungicide on susceptible varieties. 2022 Leaf Rust ratings (Table 1) ranged from 1.0 to 6.2 and averaged 2.2. Stripe Rust is caused by the pathogen *Puccinia graminis* and causes bright yellow-orange pustules that appear in linear rows along leaf veins. Infection can result in reductions in yield and test weight. Management includes planting resistant varieties and using a foliar fungicide on susceptible varieties. In 2022 there was insufficient Stripe Rust pressure to make ratings, but varieties with symptoms in more than one replicated plot was noted and considered susceptible.

**Image 1. Fusarium Head Scab infection in wheat.**

## CONCLUSION

As is evident by the 2022 disease ratings in table 1, there are wide levels of resistance or susceptibility among wheat varieties to various pathogens. When making variety selection decisions, disease reaction should be considered as the primary step in protecting the wheat crop, and thereby potentially avoiding the need for a fungicide application. This practice is a simple, sustainable and a highly effective management practice.

**Table 1. 2022 Kentucky Wheat Variety Disease Ratings.**

| Variety | Leaf Blotch | Head Scab | Glume Blotch | Powdery Mildew | Leaf Rust | Stripe Rust |
|---|---|---|---|---|---|---|
| AgriMAXX 454 | 5.3 | 3.6 | 2.0 | 6.5 | 4.2 | ** |
| AgriMAXX 492 | 8.4 | 5.7 | 2.0 | 1.0 | 1.2 | |
| AgriMAXX 503 | 4.3 | 2.0 | 2.8 | 3.8 | 1.5 | |
| AgriMAXX 505 | 4.5 | 3.5 | 4.3 | 3.0 | 4.0 | |
| AgriMAXX 511 | 4.1 | 2.4 | 2.9 | 3.0 | 1.3 | |
| AgriMAXX 513 | 5.3 | 2.3 | 3.0 | 1.0 | 2.0 | |
| AgriMAXX 514 | 6.0 | 3.5 | 3.4 | 1.3 | 2.0 | |
| AgriMAXX 516 | 5.5 | 3.5 | 2.8 | 3.0 | 2.2 | |
| AgriMAXX 525 | 4.4 | 3.3 | 2.3 | 2.0 | 2.2 | |
| AgriMAXX EXP 2105 | 3.6 | 4.0 | 3.3 | 1.5 | 1.2 | |
| CROPLAN CP8022 | 3.8 | 3.9 | 2.0 | 2.3 | 2.5 | |
| CROPLAN CP8045 | 5.5 | 3.1 | 3.3 | 3.8 | 1.5 | |
| CROPLAN CP8081 | 5.3 | 5.1 | 2.0 | 6.3 | 2.5 | |
| Dyna-Gro 9002 | 5.4 | 5.2 | 2.8 | 5.5 | 1.8 | |
| Dyna-Gro 9120 | 5.6 | 4.6 | 3.3 | 1.3 | 1.8 | |
| Dyna-Gro 9151 | 4.9 | 3.2 | 5.3 | 2.8 | 1.8 | |
| Dyna-Gro 9172 | 6.0 | 4.0 | 2.8 | 2.5 | 1.6 | |
| Dyna-Gro 9352 | 5.8 | 3.4 | 5.8 | 2.3 | 2.8 | |
| Dyna-Gro 9393 | 6.5 | 4.9 | 2.0 | 3.5 | 1.2 | |
| Dyna-Gro 9692 | 5.3 | 4.3 | 2.0 | 8.5 | 3.8 | |
| Dyna-Gro WX20738 | 7.0 | 4.3 | 2.8 | 2.5 | 1.0 | |
| Dyna-Gro WX21741 | 4.5 | 3.3 | 5.0 | 3.0 | 2.0 | |
| Dyna-Gro WX22793 | 4.5 | 4.9 | 2.0 | 2.3 | 4.2 | ** |
| Go Wheat 2058 | 7.0 | 6.1 | 3.0 | 1.0 | 2.0 | |
| Go Wheat 2059 | 6.0 | 2.0 | 2.3 | 3.3 | 2.3 | |
| Go Wheat 4059S | 4.9 | 2.5 | 3.8 | 2.0 | 1.5 | |
| Go Wheat 6056 | 5.9 | 3.2 | 3.3 | 2.3 | 1.8 | |
| GP 348 | 5.6 | 6.1 | 4.8 | 1.3 | 2.8 | |
| GP 381 | 5.0 | 5.0 | 3.8 | 1.3 | 3.3 | |
| GP 463 | 5.1 | 2.9 | 3.0 | 4.5 | 1.5 | ** |
| GP 709 | 5.9 | 5.3 | 3.0 | 1.0 | 2.7 | |
| GP 747 | 4.3 | 4.4 | 2.3 | 4.0 | 2.3 | |
| GROWMARK FS 597 | 6.8 | 4.3 | 3.0 | 3.8 | 1.3 | |
| GROWMARK FS 600 | 4.8 | 3.6 | 4.8 | 3.3 | 3.5 | |
| GROWMARK FS 603 | 5.3 | 2.5 | 5.3 | 5.3 | 2.2 | |
| GROWMARK FS 616 | 4.6 | 3.8 | 5.8 | 2.3 | 2.1 | |
| GROWMARK FS 623 | 4.1 | 1.6 | 2.8 | 3.5 | 1.5 | |
| GROWMARK FS 624 | 6.4 | 3.8 | 7.5 | 5.5 | 1.7 | |
| GROWMARK FS 745 | 5.3 | 3.8 | 2.8 | 2.5 | 2.8 | |
| GROWMARK FS WX22A | 4.8 | 3.3 | 4.0 | 1.3 | 1.5 | |
| GROWMARK FS WX22B | 5.0 | 3.1 | 4.5 | 2.3 | 1.2 | |
| KAS 20X29 | 4.4 | 3.2 | 3.5 | 1.3 | 2.2 | |
| KAS 21X56 | 5.3 | 3.8 | 3.5 | 1.3 | 1.7 | |
| KAS 21X60 | 5.1 | 4.4 | 1.8 | 2.0 | 3.5 | ** |
| KAS 21X61 | 5.5 | 3.8 | 5.5 | 2.3 | 2.5 | |
| KAS Reagan | 5.8 | 3.6 | 4.3 | 1.8 | 1.5 | |

## Table 1. 2022 Kentucky Wheat Variety Disease Ratings (continued).

| Variety | Leaf Blotch | Head Scab | Glume Blotch | Powdery Mildew | Leaf Rust | Stripe Rust |
|---|---|---|---|---|---|---|
| KWS394 | 3.6 | 2.2 | 2.5 | 1.8 | 2.3 | ** |
| KWS398 | 4.7 | 2.0 | 2.0 | 3.5 | 1.3 | |
| KWS403 | 3.3 | 2.6 | 3.0 | 1.0 | 3.8 | ** |
| KWS405 | 4.4 | 3.8 | 4.0 | 4.8 | 1.3 | |
| KWS411 | 5.8 | 4.8 | 2.3 | 1.3 | 2.9 | |
| KWS419 | 5.1 | 2.4 | 1.8 | 1.8 | 2.0 | |
| Liberty 5658 | 6.1 | 4.4 | 3.3 | 3.0 | 1.7 | |
| MI19R0003 | 8.4 | 7.6 | 3.3 | 1.3 | 2.0 | |
| MI19R0347 | 4.6 | 4.0 | 3.3 | 2.3 | 2.3 | |
| PEMBROKE 2016 | 7.1 | 4.7 | 2.3 | 2.5 | 2.2 | |
| PEMBROKE 2021 | 6.4 | 5.5 | 2.5 | 2.0 | 3.2 | |
| Revere 2169 | 5.6 | 3.2 | 3.0 | 3.5 | 2.8 | |
| Revere 2266 | 5.6 | 3.6 | 5.3 | 1.0 | 2.3 | |
| SY 100 | 6.3 | 5.3 | 4.0 | 2.7 | 2.1 | |
| SY 547 | 4.1 | 4.8 | 2.5 | 1.0 | 3.2 | |
| SY Viper | 6.3 | 5.3 | 2.5 | 2.0 | 2.2 | |
| Truman | 5.0 | 1.5 | 2.0 | 1.5 | 3.7 | |
| USG 3352 | 4.3 | 3.5 | 3.0 | 2.3 | 1.5 | |
| USG 3472 | 5.1 | 3.2 | 2.3 | 4.5 | 3.0 | |
| USG 3783 | 6.1 | 4.3 | 3.0 | 3.8 | 2.0 | |
| VA17W-75 | 5.9 | 5.1 | 2.5 | 1.0 | 1.0 | |
| WSC 2720 | 6.5 | 5.5 | 1.5 | 1.3 | 4.0 | |
| WSC 3400 | 3.8 | 3.6 | 2.5 | 1.8 | 3.5 | |
| WSC 3506 | 4.8 | 5.9 | 3.5 | 2.8 | 6.2 | |
| X11-0039-1-17-5 | 7.3 | 5.3 | 2.0 | 2.0 | 3.5 | |
| X11-0120-12-4-3 | 5.1 | 3.2 | 1.5 | 1.8 | 1.5 | |
| X11-0170-52-3-3 | 5.6 | 3.0 | 2.3 | 4.5 | 1.0 | |
| X11-0414-116-11-3 | 7.0 | 6.3 | 2.5 | 1.8 | 1.2 | |
| X12-265-56-8-1 | 5.4 | 3.2 | 1.5 | 3.3 | 3.5 | |
| X12-3010-4-4-1 | 2.6 | 4.2 | 2.5 | 1.3 | 1.2 | ** |
| X12-3014-46-7-3 | 5.8 | 4.6 | 2.0 | 1.0 | 1.0 | |
| X12-3024-47-4-5 | 5.3 | 4.3 | 2.0 | 1.5 | 1.0 | |
| X12-3048-52-18-3 | 5.5 | 5.4 | 2.5 | 2.0 | 2.7 | |
| X12-3051-53-17-3 | 5.1 | 5.2 | 2.0 | 1.8 | 2.8 | |
| X12-3072-55-13-5 | 5.0 | 4.5 | 2.5 | 1.0 | 1.0 | |
| X12-3114-65-7-1 | 5.9 | 5.5 | 2.5 | 2.5 | 1.2 | |
| X12-924-40-7-5 | 6.6 | 3.6 | 2.5 | 2.3 | 1.2 | |
| **Average** | **5.4** | **4.0** | **3.0** | **2.5** | **2.2** | |

Disease Rating scale: 1 = resistant; 9 = susceptible.

Leaf Blotch, Head Scab and Leaf Rust rated at Fayette and Logan Co., KY.

Powdery Mildew, Glume Blotch and Stripe Rust rated at Lexington, KY
** Stripe Rust observed in multiple plots.

# IMPACTS OF SULFUR FERTILIZATION ON YIELD, GRAIN QUALITY, AND N USE EFFICIENCY OF WHEAT

Dave Van Sanford*, Hanna Poffenbarger*, Paula Castellari* and John Grove**
University of Kentucky, Lexington*
*and*
University of Kentucky Research and Education Center, Princeton**

## OBJECTIVES AND MATERIALS AND METHODS

A field study was grown in the harvest years 2021 and 2022 at Spindletop Farm (LEX) and the West Kentucky Research and Education Center (PRN). The overarching objective was to determine whether applications of sulfur fertilizer (S) in combination with various levels of N fertilizer would increase yield and N use efficiency. We used a group of varieties that were known to differ to some extent in protein quality and quantity, thinking that might have an impact on the sulfur effect. In the field study grown at LEX and PRN, the following varieties were used: Pembroke 2014 (early maturity, strong gluten), Pembroke 2021 (early maturity, intermediate gluten strength), Vision 45,(mid-late maturity, strong gluten, HRW), Pioneer 26R10 (mid maturity, unknown gluten strength), and Agrimax 454 (mid - late maturity, unknown gluten strength). There were three N levels (0, 90 and 120 lb/a) and these were combined with two S levels (0 and 30 lb/a).

## RESULTS AND DISCUSSION

As we often see, the years of the study provided differing results. In 2021 the extra N at heading increased grain yield, though this was not the case in 2022. Normally we would not expect a heading application of N to increase yield but rather increase grain protein. This can vary though when conditions are favorable for initiating tillers and producing more kernels; typically this means cool nights and plenty of solar radiation. In both years of the study, the addition of sulfur plus extra N provided the highest yields.

In Table 2 we see that there are some varietal differences in response to combinations of N and S. Interestingly, Vision 45, the hard red winter wheat shows the highest percentage response to the addition of S when compared to the N only and the N extra treatment. Pembroke 2021 produced the highest yield of all varieties when treated with extra N at heading plus sulfur.

We also baked small loaves of bread in the lab of Chef Bob Perry, thinking that this study might provide insight on the possibility of a value added product. We looked at loaf volume as a function of fertilizer treatment as shown in Table 3. While loaf volume was highest in the extra N plus S treatment, the difference was not statistically significant.

In Table 4 it is apparent that loaf volume varies among varieties, with the HRW Vision 45 producing the largest volumes and thus the strongest gluten. Pembroke 2014, known to be a strong gluten SRW wheat, had the next highest volume followed by the other 3 SRW wheats.

The results of the study show that when averaged over years and locations, there was a yield increase of approximately 7.5 bushels when sulfur was added to the standard amount of N (90 lb/a) applied at growth stages 3 and 5. The data indicate that under certain conditions an extra application of N at heading can increase yield, and further, this response can be amplified by the addition of sulfur. One caveat about this study is that residual N from the previous corn crop at LEX resulted in extensive lodging in 2022, so we did not get as clean an estimate of yield as we were hoping for that year. The soil test data (not shown) tell us that Princeton sites usually have more sulfate present in the subsoil and that could be an important source of S for the wheat. In Table 5, after removing the zero N treatment and the S only treatment, the impact of S application on grain yield was assessed in the four environments: LEX 21, LEX22, PRN21 and PRN22. We do not see a significant effect at PRN either year of the study, but there was a significant yield response to S at Lexington in both years of the study.

We have not assessed economic value of the fertilizer treatment yet but that will be done in the final report that will be available on the KSGGA website.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Kentucky Small Grain Growers Association

**Table 1. Mean yield for fertilizer treatments averaged over five wheat varieties and two locations 2021-2022.**

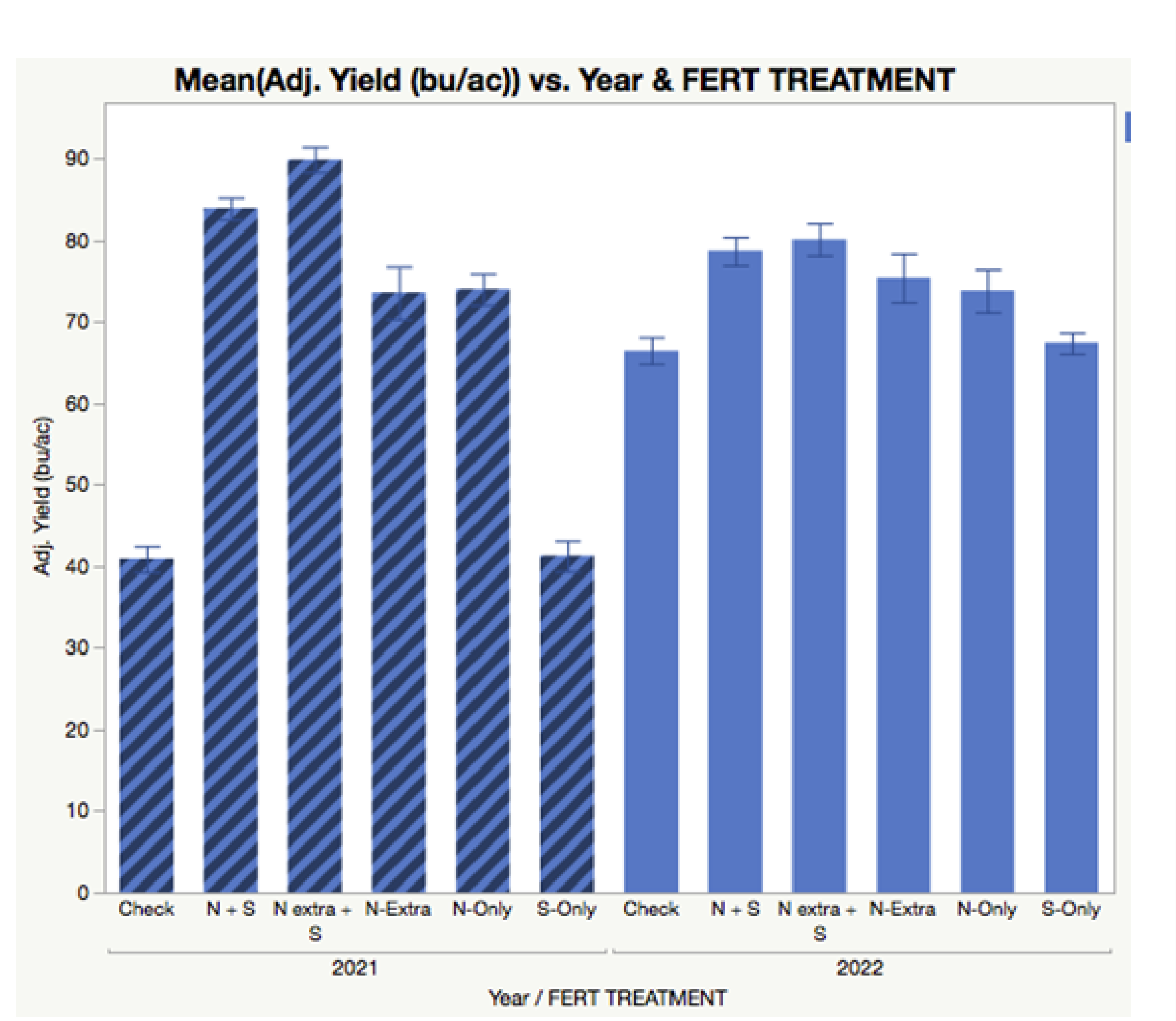


**Table 2. Wheat variety response to various levels of N and S averaged over two locations and years, 2021-2022.**

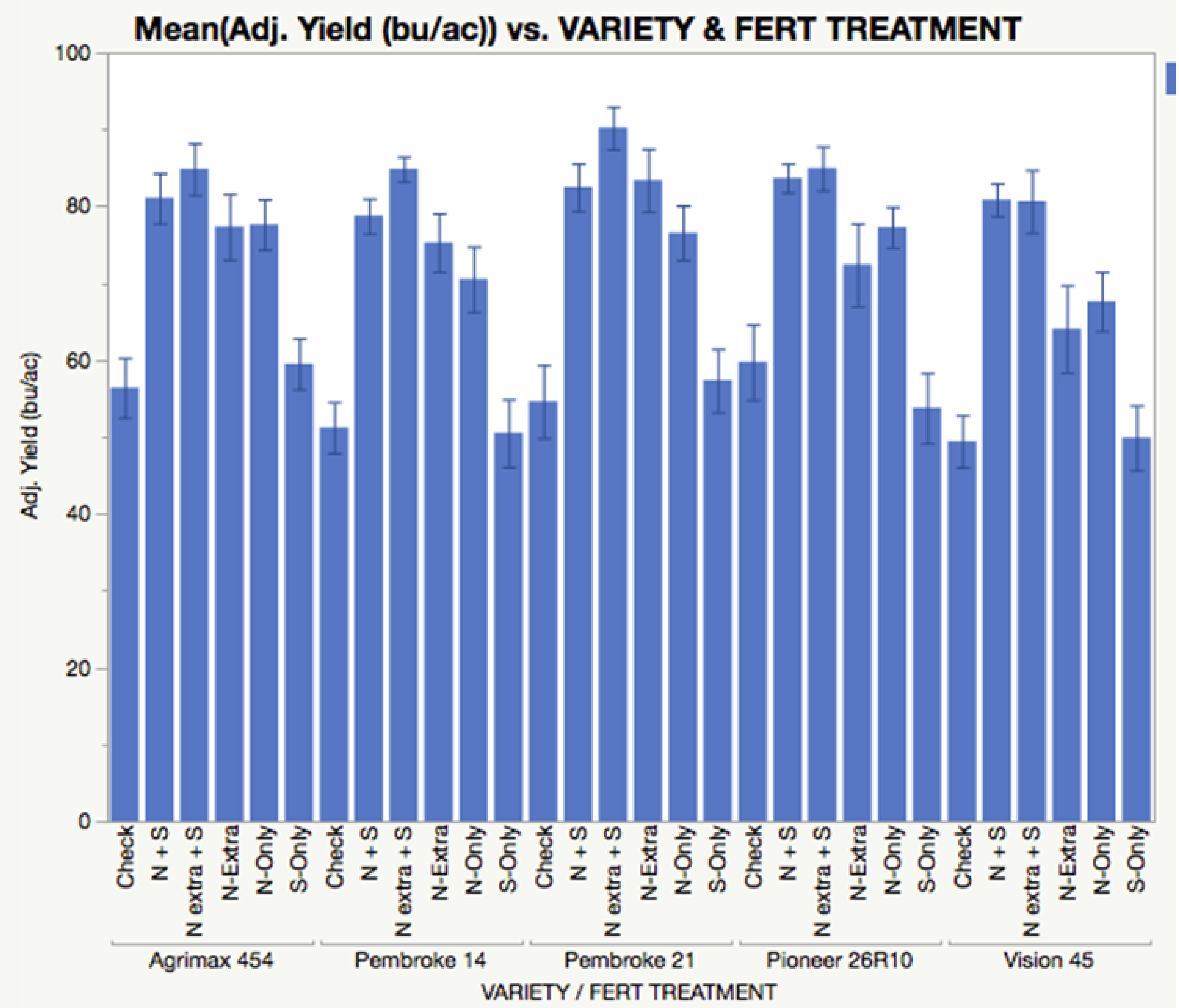


**Table 3. Effect of fertilizer treatment on loaf volume in bread baked from 5 wheat varietal flours produced at two locations, 2021-2022.**

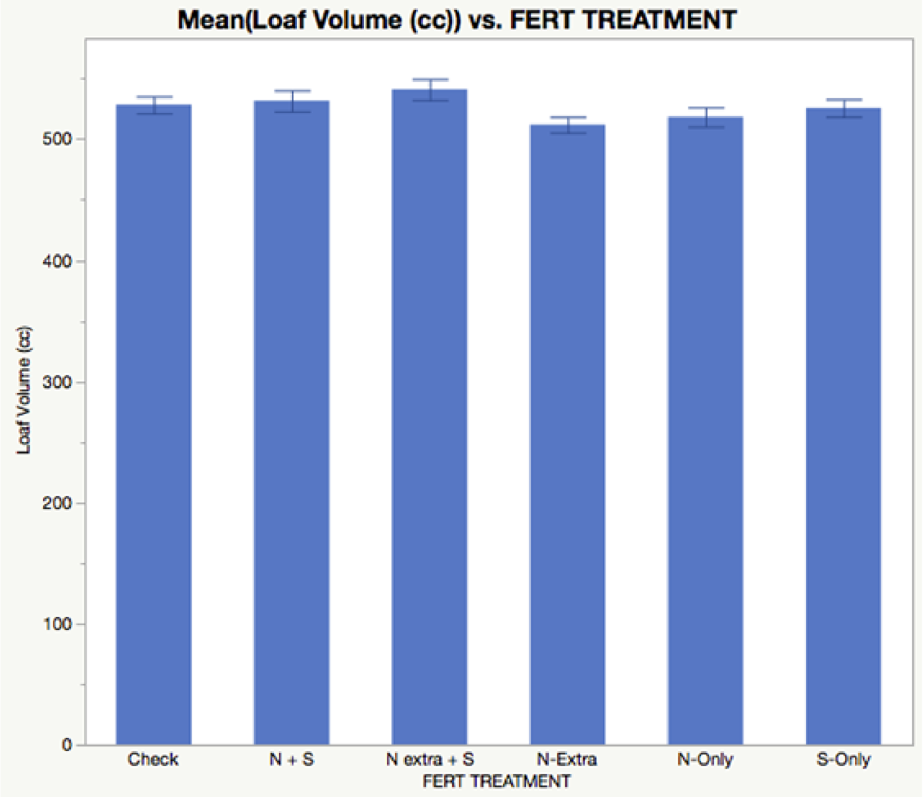


**Table 4. Loaf volume of four SRW wheats and one HRW wheat grown at two locations, 2021-2022, averaged over 6 combinations of S and N fertilizer.**

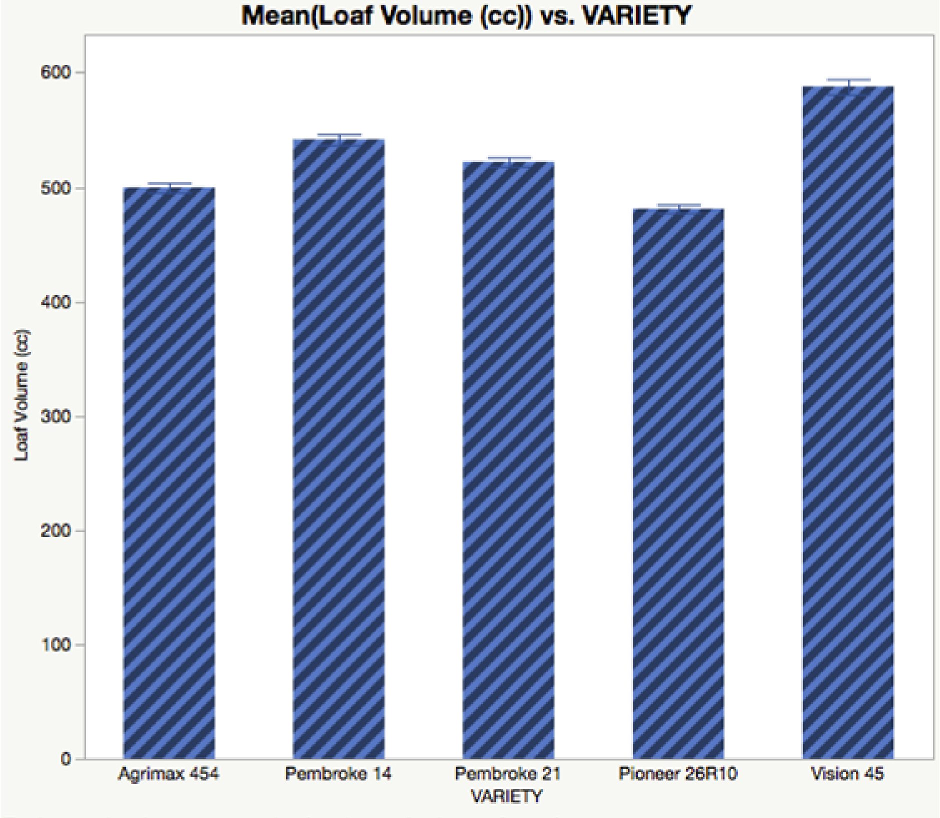
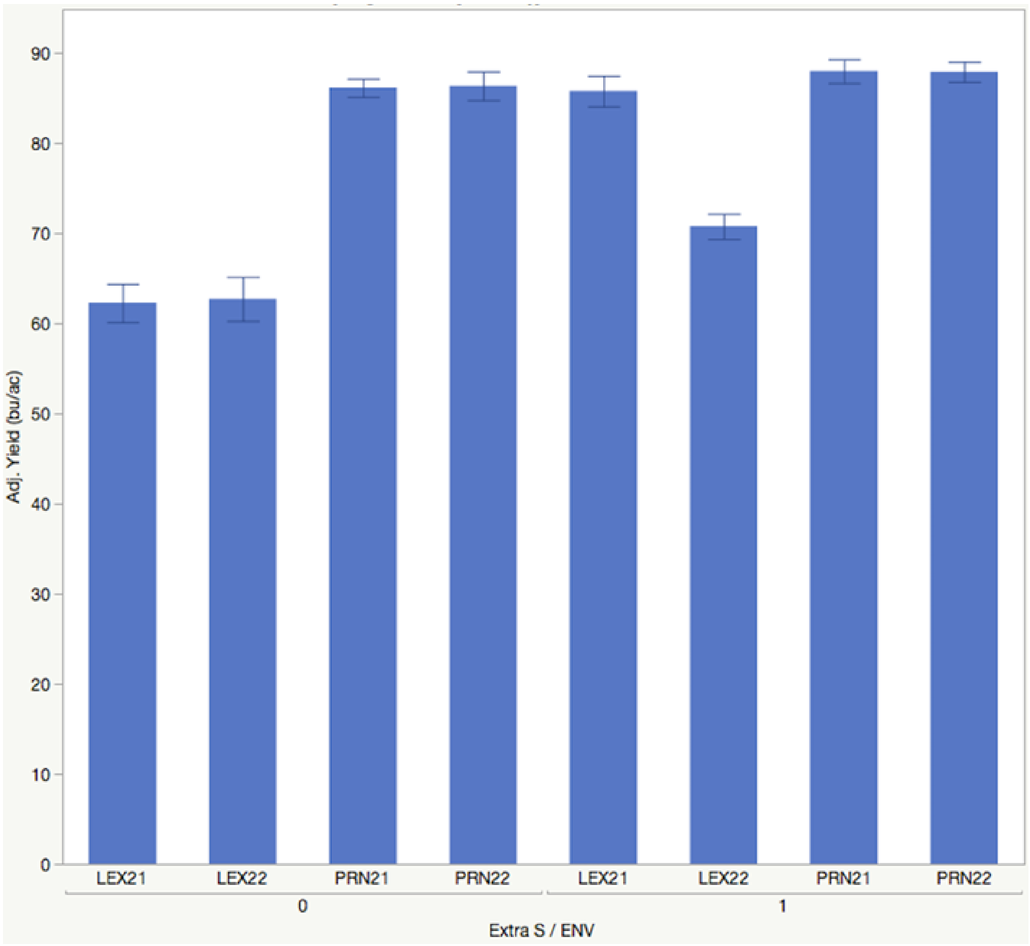


**Table 5. Impact of extra sulfur on wheat yield in four environments: Lexington and Princeton over two years, 2021 and 2022. The zero N and S only treatments were excluded from this analysis. Extra S indicated by 1, no extra S by 0.**



# WHEAT VIRUS SURVEY FOR KENTUCKY DURING THE 2022 FIELD SEASON

Carl A. Bradley, Kelsey Mehl, and Nathan White
Department of Plant Pathology, University of Kentucky, Princeton, KY 42445

## INTRODUCTION

Many viruses can affect wheat grown in Kentucky, but until 2021, it had been several years since a formal wheat virus survey has been conducted in Kentucky. A recent survey of wheat viruses present in the neighboring state of Illinois was published, where the following viruses were detected: barley yellow dwarf virus (pav and mav strains), wheat spindle streak mosaic virus, cereal yellow dwarf virus (strain rpv), wheat streak mosaic virus, and high plains virus (Kleczewski et al. 2020). A similar survey conducted in Kentucky in 2021 resulted in the following viruses being detected: barley yellow dwarf virus (pav strain), cereal yellow dwarf virus (rpv strain), and high plains wheat mosaic virus (Bradley et al. 2022). In addition, the bacterial pathogen that causes bacterial mosaic of wheat, *Clavibacter michiganensis* subsp. *tessellarius* (Cmt) was detected frequently in both the Illinois and Kentucky survey.

## METHODS & MATERIALS

Wheat leaf samples were collected from wheat 78 wheat fields, representing 23 counties (Table 1). For each field 20 leaves were sampled blindly from a 600 m transect through the field, where samples were collected every 30 m. Samples were frozen until all were accumulated, and then were delivered to Adgia Inc. (Elkhart, IN), where they were tested for eleven different viruses and Cmt using enzyme linked immunoassay (ELISA) tests.

## RESULTS

Out of the eleven viruses that were tested for, only three were found in the samples tested. High plains wheat mosaic virus was found in 13 samples (16.7%), and wheat streak mosaic virus was found in in 1 sample (1.3%). The bacterial mosaic pathogen, Cmt, was found in 77 samples (98.7%).

## CONCLUSIONS

In general, a low number of samples tested positive for any viruses. Out of the viruses detected, high plains mosaic virus was detected the most often (16.7% of samples tested). The bacterial mosaic pathogen of wheat, Cmt, was detected in nearly every wheat field tested. This is similar to what was reported by Kleczewski et al. (2020), in which Cmt was detected in a large percentage of wheat fields in Illinois. This wheat virus survey will continue in 2023, which will help determine if these viruses occur every year in a low percentage of fields.

## REFERENCES

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Kleczewski, N., Chapara, V., and Bradley, C. A. 2020. Occurrence of viruses and *Clavibacter michiganensis* in winter wheat in Illinois, 2009 to 2011 and 2019 to 2020. Plant Health Progress 21:317-320. https://doi.org/10.1094/PHP-07-20-0060-S.

## ACKNOWLEDGEMENTS

This research was funded by the Siemer Milling Company. We also express thanks to all of the University of Kentucky County Extension Agents that collected samples for testing.

## TABLES

Table 1. Counties surveyed and number of fields sampled within each county for a wheat virus survey conducted in Kentucky in 2022.

| County | No. field sampled |
|---|---|
| Adair | 1 |
| Ballard | 8 |
| Caldwell | 2 |
| Calloway | 2 |
| Carlisle | 2 |
| Christian | 8 |
| Daviess | 4 |
| Fayette | 1 |
| Fulton | 3 |
| Graves | 5 |
| Henderson | 6 |
| Hickman | 2 |
| Lincoln | 2 |
| Logan | 5 |
| Lyon | 2 |
| Marshall | 2 |
| McLean | 1 |
| Nelson | 3 |
| Simpson | 5 |
| Todd | 4 |
| Trigg | 3 |
| Union | 4 |
| Warren | 3 |

**Table 2. Results of ELISA tests for detection of viruses and the bacterial mosaic pathogen.**

| Pathogen tested | No. samples positive (out of 78) | % samples positive |
|---|---|---|
| Brome mosaic virus | 0 | 0 |
| Barley stripe mosaic virus | 0 | 0 |
| Barley yellow dwarf virus - mav | 0 | 0 |
| Barley yellow dwarf virus - pav | 0 | 0 |
| Clavibacter m. tessellarius | 77 | 98.7 |
| Cereal yellow dwarf virus - rpv | 0 | 0 |
| High plains wheat mosaic virus | 13 | 16.7 |
| Potyvirus group | 0 | 0 |
| Soilborne wheat mosaic virus | 0 | 0 |
| Tobacco mosaic virus | 0 | 0 |
| Wheat streak mosaic virus | 1 | 1.3 |
| Wheat spindle streak mosaic virus | 0 | 0 |

# EVALUATION OF FOLIAR FUNGICIDES FOR FUSARIUM HEAD BLIGHT MANAGEMENT ACROSS DIFFERENT WHEAT VARIETIES

Carl A. Bradley, Kelsey Mehl, John Walsh, and Nathan White
Department of Plant Pathology, University of Kentucky, Princeton, KY 42445

## OBJECTIVE

The primary objective of this research was to evaluate different fungicide products for Fusarium head blight (FHB) management across different wheat varieties.

## METHODS & MATERIALS

A field trial was conducted at the University of Kentucky Research and Education Center (UKREC) in Princeton, KY to evaluate the effect of different foliar fungicide treatments across different wheat varieties for management of FHB. On October 19, 2021, 6 different wheat varieties ('AgriMaxx 513', 'Croplan 9415', 'Dynagro 9941', 'Pembroke 21', 'Pioneer 26R59', and 'Pioneer 26R36' were planted at approximately 1.5 million seeds/A. Each plot was 49 inches wide (7 rows spaced 7 inches apart) and 16 ft long. Plots were planted no-till into corn stubble and were arranged in a randomized complete block design with 3 replications (blocks). Across each wheat variety, the following treatments were applied at Feekes growth stage 10.51 (anthesis), which occurred between May 7-10, 2022. The fungicide treatments included a non-treated control; Folicur (tebuconazole) at 4 fl oz/A; Miravis Ace (pydiflumetofen + propiconazole) at 13.7 fl oz/A; Caramba (metconazole) at 13.5 fl oz/A; Prosaro (prothioconazole + tebuconazole) at 6.5 fl oz/A; Prosaro Pro (prothioconazole + tebuconazole + fluopyram) at 10.3 fl oz/A; Sphaerex (metconazole + prothioconazole) at 7.3 fl oz/A; and Double Nickel LC (*Bacillus amyloliquefaciens* strain D747) at 192 fl oz/A. All treatments were applied with a backpack sprayer equipped with Twinjet 60 8002 nozzles calibrated to deliver 20 gal/A. To help ensure FHB disease pressure, plots were mist-irrigated 3 times daily for a duration of 15 minutes each from the boot stage through soft dough stage, and plots were inoculated with a spore suspension of *Fusarium graminearum* (20,000 spores/ml) the day following fungicide application. Plots were rated for FHB incidence and severity on May 19, 2022, and those data were used to calculate a FHB severity index score (0-100 scale) that were statistically analyzed. Yield, grain moisture, and test weight were obtained at harvest. Data were statistically analyzed using the General Linear Models procedure using SAS software (version 9.4). When treatments were found to be statistically significant ($P \leq 0.05$), means were compared for differences using Fisher's least significant difference (LSD) test with an alpha = 0.05. University of Kentucky Cooperative Extension recommendations were followed for nutrient and weed management.

## RESULTS AND DISCUSSION

Fusarium head blight pressure was moderate in the trial, with the FHB severity index in the nontreated controls in the different wheat varieties ranging from 2.4 to 8.3, with the lowest FHB severity index being observed in 'Dynagro 9941' and greatest in 'Pembroke 21' (Table 1). The effect of fungicides on FHB severity index varied across varieties. Compared to the nontreated control, fungicide treatments significantly ($P \leq 0.05$) reduced FHB severity index per the following for the different varieties: 4 of 6 varieties for Folicur an, Caramba, and Prosaro Pro, 3 of 6 varieties for Miravis Ace and Prosaro Pro, 2 of 6 varieties for Sphaerex, and 1 of 6 varieties for Double Nickel. Grain moisture generally was not affected by most fungicides but was significantly increased with Miravis Ace in 5 of 6 varieties, relative to the nontreated control. A significant increase in test weight, relative to the nontreated control, was observed as follows: 1 of 6 varieties for Folicur, Caramba, and Sphaerex, 2 of 6 varieties for Miravis Ace and Prosaro, 3 of 6 varieties for Prosaro Pro, and in 0 of 6 varieties for Double Nickel. A significant increase in yield, relative to the nontreated control, was observed as follows: 1 of 6 varieties for Folicur, Caramba, Prosaro, Prosaro Pro, Sphaerex, and Double Nickel, and 3 of 6 varieties for Miravis Ace.

Many of the varieties in this trial are considered to be moderately resistant to FHB. Thus, it is not surprising that minimal effects of fungicides were observed on several varieties. On the two varieties in which FHB was most severe, 'Pembroke 21' and 'Pioneer 26R36', the effects of the fungicide treatments on FHB severity index was more consistent, with almost every treatment significantly reducing FHB severity index values compared to the nontreated controls (Table 1). The level of FHB severity index observed in 'Pioneer 26R36' likely had an effect on yield response with fungicides, as every treatment significantly increased yield compared to the nontreated control.

In general, fungicides had the greatest and most consistent impacts on varieties that were observed to be more susceptible to Fusarium head blight. This study needs to be conducted over at least one more year to determine if results are consistent over different growing seasons. In addition, DON data from grain samples collected at harvest from this trial were not yet available when this report was written. Since DON contamination of grain is a serious issue, when available, these data will help provide a greater picture of the effect of the fungicide treatments across varieties.

## ACKNOWLEDGEMENTS

Support for this research came from the Kentucky Small Grain Growers Association.

**Table 1. Effect of different fungicide treatments applied at Feekes 10.51 on Fusarium head blight (FHB) severity index, grain moisture, test weight, and yield on six different wheat varieties at Princeton, KY in 2022**

| Variety | Treatment | Rate (fl oz/A) | FHB severity index (0-100) | Grain moisture (%) | Test weight (lb/bu) | Yield (bu/A) |
|---|---|---|---|---|---|---|
| AgriMaxx 513 | Nontreated | . | 3.3 | 13.6 | 59.9 | 73.9 |
| | Folicur | 4 | 0.5 | 13.7 | 59.8 | 74.7 |
| | Miravis Ace | 13.7 | 1.1 | 14.0 | 60.8 | 79.4 |
| | Caramba | 13.5 | 0.7 | 13.5 | 59.0 | 67.2 |
| | Prosaro | 6.5 | 1.9 | 13.7 | 60.0 | 68.4 |
| | Prosaro Pro | 10.3 | 0.3 | 13.8 | 61.0 | 80.7 |
| | Sphaerex | 7.3 | 1.3 | 13.6 | 59.6 | 74.7 |
| | D. Nickel | 192 | 1.2 | 13.7 | 59.3 | 71.4 |
| Croplan 9415 | Nontreated | . | 3.9 | 12.8 | 57.9 | 65.0 |
| | Folicur | 4 | 2.3 | 13.2 | 58.8 | 74.0 |
| | Miravis Ace | 13.7 | 0.8 | 14.0 | 58.8 | 80.6 |
| | Caramba | 13.5 | 0.7 | 13.4 | 60.3 | 71.6 |
| | Prosaro | 6.5 | 0.3 | 13.3 | 59.6 | 72.1 |
| | Prosaro Pro | 10.3 | 0.7 | 13.6 | 60.7 | 73.8 |
| | Sphaerex | 7.3 | 1.7 | 13.2 | 58.8 | 68.5 |
| | D. Nickel | 192 | 5.4 | 12.8 | 57.8 | 64.9 |

**Table 1 continues on next page**

Table 1 (continued)

| Variety | Treatment | Rate (fl oz/A) | FHB severity index (0-100) | Grain moisture (%) | Test weight (lb/bu) | Yield (bu/A) |
|---|---|---|---|---|---|---|
| Dynagro 9941 | Nontreated | . | 2.4 | 12.7 | 57.0 | 73.2 |
| | Folicur | 4 | 1.3 | 12.9 | 57.5 | 75.0 |
| | Miravis Ace | 13.7 | 0.9 | 13.2 | 58.4 | 80.1 |
| | Caramba | 13.5 | 0.3 | 12.8 | 56.6 | 72.6 |
| | Prosaro | 6.5 | 0.6 | 12.9 | 57.7 | 79.7 |
| | Prosaro Pro | 10.3 | 0.5 | 12.9 | 57.9 | 68.6 |
| | Sphaerex | 7.3 | 1.9 | 12.7 | 57.5 | 71.9 |
| | D. Nickel | 192 | 2.2 | 12.1 | 55.5 | 72.7 |
| Pembroke 21 | Nontreated | . | 8.3 | 12.9 | 57.0 | 56.7 |
| | Folicur | 4 | 3.1 | 13.3 | 59.1 | 54.7 |
| | Miravis Ace | 13.7 | 2.2 | 13.5 | 59.8 | 66.6 |
| | Caramba | 13.5 | 4.3 | 13.0 | 57.7 | 60.5 |
| | Prosaro | 6.5 | 3.1 | 13.1 | 58.7 | 65.0 |
| | Prosaro Pro | 10.3 | 3.9 | 13.5 | 58.9 | 64.7 |
| | Sphaerex | 7.3 | 2.3 | 13.3 | 58.7 | 61.5 |
| | D. Nickel | 192 | 7.5 | 13.0 | 57.6 | 58.1 |
| Pioneer 26R36 | Nontreated | . | 5.7 | 14.0 | 60.6 | 62.2 |
| | Folicur | 4 | 2 | 14.0 | 60.6 | 73.1 |
| | Miravis Ace | 13.7 | 0.9 | 14.5 | 61.5 | 73.3 |
| | Caramba | 13.5 | 1.3 | 14.1 | 60.6 | 72.4 |
| | Prosaro | 6.5 | 0.1 | 14.0 | 60.6 | 72.1 |
| | Prosaro Pro | 10.3 | 1.4 | 14.0 | 60.8 | 75.9 |
| | Sphaerex | 7.3 | 1.1 | 14.1 | 61.1 | 71.8 |
| | D. Nickel | 192 | 0.9 | 13.8 | 60.8 | 72.3 |
| Pioneer 26R59 | Nontreated | . | 3.7 | 13.2 | 57.3 | 68.9 |
| | Folicur | 4 | 0.9 | 13.4 | 58.3 | 71.0 |
| | Miravis Ace | 13.7 | 2.7 | 13.9 | 59.1 | 67.6 |
| | Caramba | 13.5 | 1.3 | 13.3 | 58.5 | 73.5 |
| | Prosaro | 6.5 | 1.8 | 13.3 | 57.6 | 70.9 |
| | Prosaro Pro | 10.3 | 1.5 | 13.6 | 59.0 | 73.4 |
| | Sphaerex | 7.3 | 2.1 | 13.1 | 57.2 | 66.3 |
| | D. Nickel | 192 | 2.8 | 13.0 | 57.2 | 59.8 |
| | | *P > F* | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | | LSD 0.05 | 2.8 | 0.5 | 1.5 | 9.4 |
| | | CV (%) | 82.8 | 2.2 | 1.5 | 8.3 |

# INTENSIVE WHEAT MANAGEMENT, A RESEARCH AND EDUCATIONAL OPPORTUNITY FOR KENTUCKY

Edwin L. Ritchey, Jordan M. Shockley, Jesse L. Gray and John H. Grove
University of Kentucky Research and Education Center, Princeton

## OBJECTIVE

The objectives of this study were to determine: 1. If newer varieties with higher yield potential require or tolerate a greater nitrogen (N) rate to maximize yields 2. If N management influences the potential for spring freeze damage and lodging potential; 3. If the use of a plant growth regulator (e.g. Palisade) is needed along with high N rates to maximize yields; 4. If attempting to maximize wheat yield results is economically sustainable?

## METHODS & MATERIALS

Wheat was produced with an intensive N management approach on a Crider silt loam soil with 0-2 percent slope, following corn. Wheat was established on October 20, 2021, using a Great Plains 706NT drill with a 7.5 inch row spacing. The experimental design was a randomized complete block with three splits. The main plot was variety, two high yielding modern hybrids (Pioneer 26R59 and Agri-Max 454), chosen using results provided by the UK Small Grains Variety Testing Program. The first split was fall N rate (0, 30 or 60 lb N/A). The second split was spring N rate (50, 100, and 150 lb N/A). The final split was the use of a plant growth regulator (Palisade). All treatment combinations were replicated four times.

The fall N application was made with urea (46-0-0) using a Gandy drop spreader on November 24, 2021. The spring N applications were applied as UAN (28-0-0) using a sprayer equipped with stream bars. The applications were in 50 lb N/A increments. The 50 lb N/A treatment was applied on March 3, when most of the wheat was at the growth stage Feekes 3-4. The 100 lb N/A treatment was applied as 50 lb N/A on February 15 at Feekes 2, followed by a second 50 lb N/A on March 25 at Feekes 4-5. The 150 lb N/A treatment was applied on February 15 at Feekes 2, followed by a second application on March 25 at Feekes 4-5, and a third application on April 1 at Feekes 7.

Normalized differential vegetative index (NDVI) readings were collected using a handheld Trimble GreenSeeker immediately prior to each spring N application. The GreenSeeker sensor was held approximately 3 ft above the wheat canopy and NDVI measurements were averaged across the entire plot. The middle 6 rows of wheat were harvested with a SPC-40 Almaco plot combine. Wheat grain weight, grain moisture and test weight were collected and wheat yields are reported at 13.5% moisture. Treatment differences and interactions were evaluated statistically with SAS Version 9.4 (Cary, NC).

As recommended, Harmony Extra herbicide, Caramba fungicide and Warrior insecticide was applied for spring weed control, fusarium head scab prevention, and for aphid control, respectively. Additional fungicide may have been warranted, based on disease indicators present at harvest.

Partial budgeting was performed to determine the net benefit of different management strategies as compared to the base scenario. The underlying assumptions used for the economic analysis include: $1.00/lb N with an application cost of $7.50/A. Palisade plant growth regulator at $1.33/fl oz using a rate of 14.4 fl oz/A and an application costs of $8.50/A, and a wheat grain price of $6.40/bu. The economic comparison was done within each variety. The “base treatment” used in comparison with the other treatments received 30 lb fall N/A, 100 lb spring N/A and no Palisade.

## RESULTS AND DISCUSSION

The NDVI results are presented in Table 1. The NDVI is an indication of canopy density and canopy greenness, related to both N status and general health of the wheat. However, greater NDVI values don't always translate into greater yields. Differences in NDVI were detected at the first three readings, but not at the last reading (data not shown). The first NDVI reading reflected the fall N treatments and environmental conditions present prior to the first spring N application. The Agri-Max 454 variety generally had higher NDVI readings than the Pioneer 26R59 as a main effect and also in interactions with the N rate treatments. The treatments that received fall N (30 or 60 lb N/A) exhibited in higher NDVI ratings than the treatments that received no fall N (Table 1). This result was consistent across the first three NDVI readings and within the significant variety by spring N interaction. The response to fall N addition was consistent with current UK N fertility recommendations for wheat - no benefit to adding more than 40 lb fall N/A. It is interesting that no main effect of spring N was detected in the NDVI values, only significant interactions with other treatment factors. In those interactions, spring wheat N application at 100 or 150 lb N/A maximized NDVI in both varieties.

There were significant yield differences for the main effects of variety, fall N, spring N and Palisade. Significant interactions were present for variety * spring N and fall N * spring N (Table 2). Although the Agri-Max 454 resulted in greater NDVI values than the Pioneer 26R59, it gave significantly lower yields. This stresses the importance of knowing that NDVI can be used to monitor plant health and the need for N nutrition (when the proper protocol is followed), but NDVI doesn't necessarily relate to observed yield differences. There are a couple of potential reasons for the discrepancy between NDVI and wheat yield values. First, greater biomass and greener foliage (which results in larger NDVI values) does not necessarily result in greater yield. However, there is likely another underlying reason, unrelated to treatment application - a late season infestation of Barley Yellow Dwarf Virus (BYDV) and Septoria leaf spot. Both Agri-Max 454 and Pioneer 26R59 respond well to intensive management, but the Agri-Max 454 is more susceptible to foliar diseases, as was the case in this study. Although a single fungicide application was made, a second application would have likely benefited the wheat yield.

Similar to NDVI, yield increased with increasing N rates in both the fall and spring (Table 2). There was roughly a 4 to 5 bu/A yield increase with each additional 50 lb N/A. Although this is an interesting result, the more important result is the Fall N * Spring N interaction (Table 2). Yield was maximized when 150 lb spring N/A was used with no fall N, at 30 lb fall N/A with 100 lb spring N/A or more, and with any rate of spring N at 60 lb fall N/A (Table 2). This indicates that there was a benefit to a fall N application in the 21-22 wheat production season. However, the lack of fall N could be overcome with a high rate of spring N (150 lb/A). The spring N application increased yield of both varieties, but Pioneer 26R59 resulted in greater overall yields within a given spring N rate (Table 2). The Palisade treatment reduced wheat yield in this environment. The yield reduction was likely due to a later than recommended application, when the majority of the wheat was at Feekes 8 to Feekes 9.

The economics of the study didn't favor high inputs this year (Table 3). The base rate (30 lb fall N/A, 100 lb spring N, and no Palisade) used for comparison purposes performed as well as almost all other treatment combinations. Although Pioneer 26R59 had higher overall yields than Agri-Max 454, there was no economic benefit to more N than that provided by the base treatment (Table 3). The high wheat price ($6.40/bu) did not offset high input costs, and greater input use did not increase yields enough to increase profitability. With the Agri-Max 454 variety only four treatments resulted in greater profitability than the base treatment, ranging from $6.36 to $26.36 per acre. Yields were not as high as expected for this site and wheat might have responded (yield and economic) to more intensive management, but this is not known. The N treatments most closely aligned to current UK recommendations (30 lb spring N/A and 100 lb fall N/A) provided the greatest return on investment with the Pioneer variety and the fifth highest return per acre with the Agri-Max variety.

## CONCLUSIONS

A very productive Crider silt loam soil was used for this study. This soil has the potential to produce 100+ bu/A wheat yields. However, wheat in this study gave moderate yields despite higher than normal N rates in the fall and spring. It is important to note that the price of N reached record highs during the study period, which influenced the economic viability of alternative management strategies studied herein. The late application of Palisade plant growth regulator did not benefit wheat yield. For the 2021-2022 wheat growing season, recommendations that were close to the current UK recommendations appeared to come close to optimizing economic returns. This study will be expanded in the 2022-2023 growing season and conducted again following both corn and soybean. The study will also more intensively manage foliar diseases and insects.

## ACKNOWLEDGEMENTS

We thank Siemer Milling Company for financially supporting this project.

**Table 1. Normalized Differential Vegetative Index (NDVI) for treatment effects.**

| NDVI Collection Time/Variable | Pr>F | NDVI Reading |
|---|---|---|
| **NDVI 1** | | |
| **Variety** | 0.0256 | |
| Pioneer 26R59 | | 0.374 a |
| Agri-Max 454 | | 0.396 b |
| **Fall N** | 0.0136 | |
| 0 N | | 0.367 a |
| 30 N | | 0.387 b |
| 60 N | | 0.401 b |
| **NDVI 2** | | |
| **Variety** | <0.001 | |
| Pioneer 26R59 | | 0.4088 a |
| Agri-Max 454 | | 0.4413 b |
| **Fall N** | <0.001 | |
| 0 N | | 0.3902 a |
| 30 N | | 0.4300 b |
| 60 N | | 0.4548 c |
| **Variety*Fall N** | 0.0581 | |
| Pioneer 26R59 * 0N | | 0.363 a |
| Pioneer 26R59 * 30N | | 0.413 b |
| Pioneer 26R59 * 60N | | 0.451 c |
| Agri-Max 454 * 0N | | 0.418 b |
| Agri-Max 454 * 30N | | 0.447 c |
| Agri-Max 454 * 60N | | 0.459 c |
| **Variety*Spring N** | 0.012 | |
| Pioneer 26R59 * 50N | | 0.363 a |
| Pioneer 26R59 * 100N | | 0.413 b |
| Pioneer 26R59 * 150N | | 0.451 c |
| Agri-Max 454 * 50N | | 0.418 b |
| Agri-Max 454 * 100N | | 0.447 c |
| Agri-Max 454 * 150N | | 0.459 c |
| **NDVI 3** | | |
| **Fall N** | 0.001 | |
| 0 N | | 0.556 a |
| 30 N | | 0.607 b |
| 60 N | | 0.614 b |

**Table 2. Yield (bu/A) for treatment effects and interactions.**

| Variable | Pr>F | Yield (bu/A) |
|---|---|---|
| **Yield** | | |
| **Variety** | <0.001 | |
| Pioneer 26R59 | | 80.1 b |
| Agri-Max 454 | | 69.6 a |
| **Fall N** | <0.001 | |
| 0 N | | 70.3 a |
| 30 N | | 75.1 b |
| 60 N | | 79.2 c |
| **Spring N** | <0.001 | |
| 50 N | | 70.9 a |
| 100 N | | 74.3 b |
| 150 N | | 79.4 c |
| **Variety * Spring N** | 0.012 | |
| Pioneer 26R59 * 50N | | 74.9 b |
| Pioneer 26R59 * 100N | | 82.0 c |
| Pioneer 26R59 * 150N | | 83.6 c |
| Agri-Max 454 * 50N | | 66.9 a |
| Agri-Max 454 * 100N | | 66.7 a |
| Agri-Max 454 * 150N | | 75.2 b |
| **Palisade** | <0.001 | |
| No | | 78.0 b |
| Yes | | 71.7 a |
| **Fall N * Spring N** | 0.060 | |
| 0 N * 50 N | | 64.9 a |
| 0 N * 100 N | | 66.9 ab |
| 0 N * 150 N | | 79.0 c |
| 30 N * 50 N | | 70.8 b |
| 30 N * 100 N | | 76.6 c |
| 30 N * 150 N | | 77.8 c |
| 60 N * 50 N | | 76.9 c |
| 60 N * 100 N | | 79.4 c |
| 60 N * 150 N | | 81.3 c |

**Table 3. The net benefit ($/A) over the base treatment[1] for each variety.**

| Variety | N Fall | N Spring | Total N | Palisade | Net Benefit ($/A) |
|---|---|---|---|---|---|
| Pioneer 26R59 | 0 | 50 | 50 | no | -11.25 |
| Pioneer 26R59 | 0 | 100 | 100 | no | -20.70 |
| Pioneer 26R59 | 0 | 150 | 150 | no | -15.87 |
| Pioneer 26R59 | 0 | 50 | 50 | yes | -108.37 |
| Pioneer 26R59 | 0 | 100 | 100 | yes | -124.31 |
| Pioneer 26R59 | 0 | 150 | 150 | yes | -102.95 |
| Pioneer 26R59 | 30 | 50 | 80 | no | -25.84 |
| Pioneer 26R59 | 30 | 100 | 130 | no | base |
| Pioneer 26R59 | 30 | 150 | 180 | no | -68.42 |
| Pioneer 26R59 | 30 | 50 | 80 | yes | -77.89 |
| Pioneer 26R59 | 30 | 100 | 130 | yes | -88.23 |
| Pioneer 26R59 | 30 | 150 | 180 | yes | -195.71 |
| Pioneer 26R59 | 60 | 50 | 110 | no | -37.78 |
| Pioneer 26R59 | 60 | 100 | 160 | no | -54.68 |
| Pioneer 26R59 | 60 | 150 | 210 | no | -50.92 |
| Pioneer 26R59 | 60 | 50 | 110 | yes | -85.30 |
| Pioneer 26R59 | 60 | 100 | 160 | yes | -69.43 |
| Pioneer 26R59 | 60 | 150 | 210 | yes | -149.42 |
| | | | | | |
| Agri-Max 454 | 0 | 50 | 50 | no | 20.91 |
| Agri-Max 454 | 0 | 100 | 100 | no | -40.92 |
| Agri-Max 454 | 0 | 150 | 150 | no | 10.25 |
| Agri-Max 454 | 0 | 50 | 50 | yes | -27.10 |
| Agri-Max 454 | 0 | 100 | 100 | yes | -88.36 |
| Agri-Max 454 | 0 | 150 | 150 | yes | -56.74 |
| Agri-Max 454 | 30 | 50 | 80 | no | 6.36 |
| Agri-Max 454 | 30 | 100 | 130 | no | base |
| Agri-Max 454 | 30 | 150 | 180 | no | -0.66 |
| Agri-Max 454 | 30 | 50 | 80 | yes | -26.81 |
| Agri-Max 454 | 30 | 100 | 130 | yes | -87.67 |
| Agri-Max 454 | 30 | 150 | 180 | yes | -81.06 |
| Agri-Max 454 | 60 | 50 | 110 | no | 26.36 |
| Agri-Max 454 | 60 | 100 | 160 | no | -12.65 |
| Agri-Max 454 | 60 | 150 | 210 | no | -65.71 |
| Agri-Max 454 | 60 | 50 | 110 | yes | -5.17 |
| Agri-Max 454 | 60 | 100 | 160 | yes | -88.19 |
| Agri-Max 454 | 60 | 150 | 210 | yes | -94.48 |

[1] Base treatment includes 30 lb fall N/A, 100 lb spring N/A and no Palisade for each treatment.

# GENETIC IMPROVEMENT OF CEREAL RYE: AGRONOMIC TRAITS AND END USE ATTRIBUTES

Tim D. Phillips, Elzbieta Szuleta, and David Van Sanford
University of Kentucky, Lexington

## OBJECTIVE

One of our objectives is to evaluate yield potential of several new cereal rye populations that we have developed in replicated grain yield plots. A second objective is to continue making improvements in our new populations by selecting for higher seed weight per spike and more tillers per plant. We are using dwarfing genes in some of our populations to reduce lodging. We have used speed breeding in cereal rye to improve intermating and genetic isolation.

## METHODS & MATERIALS

Seed developed from our breeding program was used to plant four yield trials, using several hybrids (KWS Daniello, KWS Bono, KWS Brasetto) and open pollinating population varieties (Aroostook, Danko, Aventino, Wheeler) along with nearly 100 test populations. Four replications of plots (4 feet by 20 feet with 7 rows spaced at 6 inches) were used. Seeding rates were at the lower end of the recommended range. Plots were fertilized with a low to moderate level of nitrogen in early March (35 #N/ac.). Grain was harvested when all entries were mature. Lodging was not a serious problem during the 2022 production year.

## RESULTS AND DISCUSSION

Grain yields were better than we have seen in Lexington in our yield trials, even with a low level of fertilization and a lighter seeding rate. Several of our new populations had yields that were not statistically different from the yield of hybrid cultivars. In one trial, KYSC1503C0 yielded 70 bu/A, more than the ~60 bu/A average for the three hybrid varieties and 58 bu/A for two open-pollinating varieties (Aroostook and Danko). We are very encouraged that some of our populations have shown competitive yields. Thirty populations were used for an additional round of selection for improved spike fertility, measured by seed weight per spike. We snapped 300 heads per population, weighted them, and keep the top 30%. Six populations were selected from spaced-planted nurseries for higher tiller number, low lodging, and shorter plant height. Two populations were intermated in isolation in the lab over the winter using LED grow lights and long daylengths in a test of speed breeding's potential use in rye.

## CONCLUSION

Progress has been made in developing new, open-pollinated (OP) cereal rye varieties for use in Kentucky. Our goal is to produce OP populations that are competitive with hybrid varieties in yield and quality, especially when grown under average production input levels. Additional yield trials in multiple locations will be used to confirm this year's promising results.

## ACKNOWLEDGEMENTS

We acknowledge the support of the Kentucky Small Grain Growers Association for funding this research and thank Gene Olson for helping plant the rye yield trials.

# RYE PLANTING DATE IN KENTUCKY, 2021-2022

PI: Chad Lee, Technician: Maria Julia Santoro and Matthew Piersawl
University of Kentucky, Lexington

## INTRODUCTION

With more interest in growing rye for grain in the United States, four universities are examining the planting dates of rye to better understand crop development in rye. This study involves the following principal investigators:

1. Jochum Wiersma, University of Minnesota
2. Shawn Conley, University of Wisconsin
3. Laura Lindsey, The Ohio State University
4. Chad Lee, University of Kentucky

## METHODS AND MATERIALS

*Lexington*

Rye was planted into a Bluegrass Maury silt loam at 2 to 6% slopes.

Seeding dates included:

1. September 17, 2021
2. October 1, 2021
3. October 19, 2021
4. November 29, 2021

Seeding Rates included the following target seeds per acre:

1. 400,000
2. 600,000
3. 800,000
4. 100,000
5. 120,000

Muriate of potash (0-0-60) was applied to the field before planting according to soil test recommendations and nitrogen rates were applied at Feekes 3 growth stage. Fertilizer phosphorus was not required. Rye was harvested with a Wintersteiger Classic combine. Seed weights were measured on a digital scale and seed moisture and test weight were measured with a Perten AM 5200.

## RESULTS

Rye seeded October 19 yielded the greatest, followed by rye seeded October 1 and then September 17 (Table 1). Rye seeded in November 29, 2021 did not survive the winter. Temperatures dipped below freezing 2 of the four nights following the latest planting (Figure 1). Temperatures fluctuated from lows in the 50's to lows below 26 F over the next weeks, allowing the latest planting of rye to emerge and not survive the subsequent freezes.

Lodging was least for rye seeded October 19, 2021, which corresponded with the highest yields.

When averaged across all seeding dates, rye seeded at 1,200,000 seeds per acre yielded the greatest followed rye seeded at 1,000,000 and 600,000 seeds per acre (Table 1). Rye seeded at 400,000 seeds per acre yielded the least. Plant lodging did not increase as seeding rates increased. Seeding rate did not affect plant lodging.

When evaluated by seeding date, rye in the first two seeding dates responded better to higher yields (Figure 2). Rye seeded October 19 yielded greatest at 100,000 seeds per acre.

**Figure 1.**
**Weather at Spindletop Farm, Lexington, KY from September 15, 2021 to December 31, 2021.**

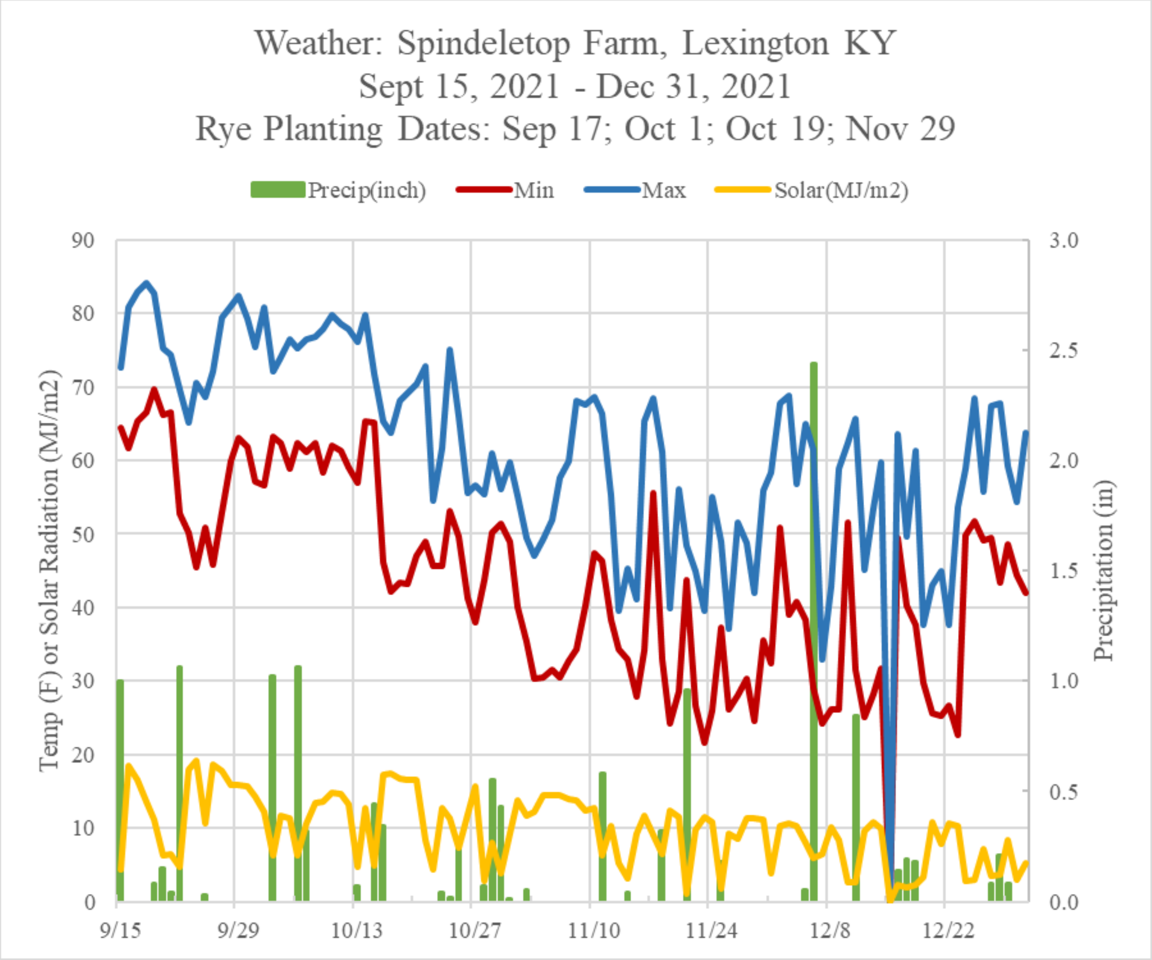
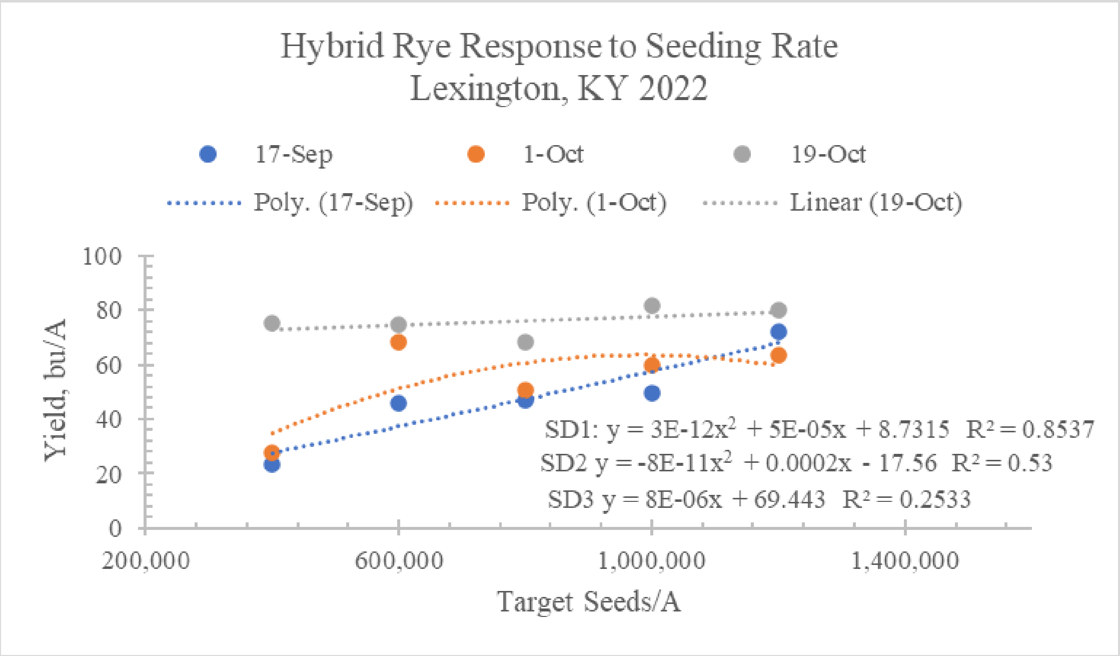


**Table 1. Seeding Date and Rate Effects on Hybrid Rye Lodging and Yield, Lexington, KY 2022.**

| Treatment | YIELD | | LODGING | |
|---|---|---|---|---|
| | Bu/A | | (0-9) | |
| **Seed Date Effect** | | | | |
| SD1 - Sept. 17 | 47.5 | b | 4.2 | b |
| SD2 - Oct. 1 | 54.0 | b | 7.5 | a |
| SD3 - Oct. 19 | 75.9 | a | 3.2 | c |
| **Seeding Rate Effect** | | | | |
| 400K seeds/acre | 42.2 | c | 4.9 | a |
| 600K | 63.0 | ab | 5.1 | a |
| 800k | 55.3 | bc | 5.4 | a |
| 1000K | 63.5 | ab | 4.8 | a |
| 1200K | 71.7 | a | 4.3 | a |
| *LSD (0.10) SD* | *11.04* | | *0.94* | |
| *LSD (0.10) SR* | *14.25* | | *1.22* | |
| *P value SD* | *0.0002* | | *<.0001* | |
| *P value SR* | *0.0156* | | *0.6737* | |
| *P value SDxSR* | *0.4816* | | *0.6596* | |
| *Means are compared within Seeding Date and Seeding Rate.* | | | | |
| *Means in the same column with different letters are significantly different (p≤ 0.10).* | | | | |

**Figure 2. Hybrid rye yield response to seed rate for each seeding date at Lexington, KY 2022.**



## DISCUSSION

The results from 2022 harvest conflict with results from studies in previous years where September planting dates normally resulted in the best yields. In addition, rye normally yielded well at target seeding rates as low as 600,000 seeds per acre and little to no yield increase from higher seeding rates. Rye in the 2022 harvest experienced some freeze damage, which is why rye in the December seeding date did not survive. Rye lodged more this year than the last three or four years. That plant lodging may have confounded other results.

We expect to repeat the trials again in 2022-2023 and compare crop phenology along with yield across the states involved in the trials.

## ACKNOWLEDGEMENTS

We thank KWS Seeds, Inc. for their support of this research. We thank Ashley Hadley, undergraduate student, for her help with this project and Dr. Tim Phillips for harvesting the trial when our combine needed repairs.

# RYE CROP AND DISEASE MANAGEMENT TRIALS IN KENTUCKY, 2021-2022

Co-PI's: Chad Lee, Carl Bradley, and Carrie Knott
Technicians: Maria Julia Santoro, Matthew Piersawl, John Walsh, Kelsey Mehl, Nathan White, Conner Raymond, and Kinsey Hamby
University of Kentucky

## INTRODUCTION

Farmers and distillers are interested in growing and buying cereal rye for grain. Cereal rye fits into a winter crop rotation scheme. Consistency of yield and grain quality must be obtained for farmers to grow rye and for distillers to have confidence in a local supply chain. Previous studies have determined that hybrid rye yields better than lines; 750,000 to 800,000 seeds per acre is sufficient for hybrid rye; and nitrogen rates of about 75 pounds N per acre are adequate. However, nitrogen rate responses are more inconsistent. Hybrid rye in Kentucky is susceptible to Fusarium head blight. These studies are being conducted to identify rye response to foliar fungicides and crop response to fertilizer nitrogen and sulfur.

## METHODS AND MATERIALS

*Lexington*

Rye was planted September 29, 2021 into a Bluegrass Maury silt loam at 2 to 6% slopes.

For the crop management trial, treatments included rye seeded at 600 and 800 thousand seeds per acre.

Fertilizer treatments included

1. 75 lb N/acre;
2. 75 lb N/acre + 20 lb S/acre;
3. 150 lb N/acre; and
4. 150 lb N/acre + 30 lb S/acre.

Muriate of potash (0-0-60) was applied to the field before planting according to soil test recommendations. No phosphorus was needed. Nitrogen fertilizer was applied at the specified rates at Feekes 3 growth stage on March 24, 2022. Miravis Ace fungicide (pydiflumetofen and propiconazole) was applied at anthesis (Feekes 10.51) on May 13, 2021 at 13.7 fluid ounces per acre (1.0 L per hectare). Rye was harvested with a Wintersteiger Delta combine on June 28, 2021, using a Harvest Master weighing system that measured grain weight, test weight, and seed moisture.

For the fungicide trial, five hybrids and one variety were planted at 800,000 seeds per acre on October 1, 2021. Fungicide treatments include:

1. Tilt fungicide was applied at flagleaf (April 22, 2022),
2. Miravis Ace applied at anthesis (May 13, 2022),
3. Tilt at flagleaf and Miravis Ace at anthesis
4. Untreated Check

Rye was harvested started on June 29, 2022 and completed on July 15, 2022 after combine failure and repairs. ). Rye was harvested with a Wintersteiger Delta combine on June 28, 2021, using a Harvest Master weighing system that measured grain weight, test weight, and seed moisture.

### *Princeton*

At Princeton, rye trials were planted on a Crider silt loam and a Zanesville silt loam (two locations). Fertilizer treatments included:

1. 75 lb N/acre;
2. 75 lb N/acre + 20 lb S/acre; and
3. 20 lb S/acre

Nitrogen was split-applied applied at Feekes 3 and Feekes 5 growth stages at Princeton. Miravis Ace fungicide was applied at anthesis. Rye was harvested with a Wintersteiger Delta combine using a Harvest Master weighing system that also measured moisture and test weight (seed density). Seed samples were run on a Dickey-John GAC to confirm seed moisture and test weight.

For the fungicide trial, five hybrids and one variety were planted at 800,000 seeds per acre. Fungicide treatments included:

1. Tilt fungicide was applied at flagleaf (April 15, 2022),
2. Miravis Ace applied at anthesis (SH3 on April 29, 2022; all others on May 10, 2022),
3. Tilt at flagleaf and Miravis Ace at anthesis
4. Untreated Check

Miravis Ace fungicide was applied at flagleaf, at anthesis, or at both timings. These treatments were compared with an untreated check for each hybrid or variety. Rye was harvested with a Wintersteiger Delta combine using a Harvest Master weighing system that also measured moisture and test weight (seed density). Seed samples were run on a Dickey-John GAC to confirm seed moisture and test weight.

## RESULTS

### *Nitrogen and Sulfur Effects*

At Lexington, yields were low at about 55 bushels per acre on average (Table 1). Yields were not affected by seed rate, by nitrogen rate or by the addition of sulfur fertilizer. Lodging was severe and freeze damage was erratic in the plots with average lodging ranging from 5.3 to 6.9. For references, rating of 9 means that every plant is fallen flat on the soil. Ratings above 5 suggest severe lodging across all treatments and suggest that lodging was not a result of the treatments imposed. Freeze damage was assessed as well. Heads and stems likely were compromised from that damage. In a separate planting date study, rye planted at the same time also lodged whereas rye planted later did not.

### Table 1. Rye at the Higher Seeding Rate had less Lodging but Yield was not Affected by Seed Rate and Nitrogen or Sulfur Applications, Lexington, KY 2022.

| Treatment | Yield, bu/A | | Lodging, 0-9 (9=all lodged) | |
|---|---|---|---|---|
| **Seed Rate Effect, seeds/A** | | | | |
| 600,000 seeds/acre | 55.7 | a | 6.8 | a |
| 800,000 seeds/acre | 57.7 | a | 5.4 | b |
| **Fertility Effect, lb/A** | | | | |
| 75 N + 0 S | 59.5 | a | 6.9 | a |
| 75 N + 20 S | 51.9 | a | 5.9 | a |
| 150 N + 0 S | 56.5 | a | 6.4 | a |
| 150 N + 30 S | 59.1 | a | 5.3 | a |
| *LSD (0.10) SR* | *15.43* | | *1.12* | |
| *LSD (0.10) FERT* | *21.82* | | *1.58* | |
| *P value SR* | *0.8254* | | *0.0374* | |
| *P value FERT* | *0.9291* | | *0.3500* | |
| *P value SRxFERT* | *0.7969* | | *0.5789* | |

*Means are compared within Seeding Rate and Fertility.*

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

### Table 2. Hybrid Rye Yield and Test Weight was Not Affected by Nitrogen or Sulfur Applications, Princeton, KY 2022.

| Soil | Fertility, lb/A | Yield, bu/A | | Test Weight, lb/bu | |
|---|---|---|---|---|---|
| **Crider** | 75 N + 0 S | 86.2 | a | 49.0 | a |
| | 75 N + 20 S | 88.7 | a | 50.5 | a |
| | 0 N + 20 S | 86.6 | a | 50.5 | a |
| | LSD (0.10) | 14.6 | | 2.1 | |
| | p value | 0.9463 | | 0.3503 | |
| **Zanesville** | 75 N + 0 S | 51.3 | a | 53.3 | a |
| | 75 N + 20 S | 58.4 | a | 53.1 | a |
| | 0 N + 20 S | 41.9 | a | 53.1 | a |
| | LSD (0.10) | 11.1 | | 2.1 | |
| | p value | 0.0952 | | 0.3503 | |

*Fungicide Effects*

At Lexington, fungicide application did not affect grain yield (Table 3). Plant lodging was inconsistent across the trials and freeze damage occurred as well, likely causing the lodging. The yields are likely a reflection of freeze damage and lodging rather than fungicide. FHB Index was less than 10.2 for all treatments, indicating very low pressure from Fusarium Head Blight.

At Princeton, rye yields were generally better than at Lexington (Table 4). Plant lodging was greater for Aventino and Bono, while the other four hybrids had little or no plant lodging. Fungicides improved yields for some of the hybrids and varieties including Serafino, SH3, and Receptor. FHB Index was greater for the treatments that did not include Miravis Ace at anthesis. FHB Index was less than 11 for all treatments, indicating low pressure from Fusarium Head Blight.

**Table 3. Rye hybrid/variety response to fungicide timing at Lexington, KY, 2022.**

| **Variety** | **Fung trt** | **Fungicide** | **6/1/2022 FHB incidence (%)** | **6/1/2022 FHB severity (%)** | **6/1/2022 FHB index (0-100)** | **Yield bu/A** | **Lodging, 0-9 (9=all lodged)** |
|---|---|---|---|---|---|---|---|
| Aventino | Flag leaf | Tilt | 3.2 | 16.0 | 0.6 | 44.1 | 8.5 |
| Aventino | Anthesis | Miravis Ace | 6.4 | 29.3 | 2.2 | 42.8 | 8.5 |
| Aventino | FL + Anth | Tilt fb Miravis Ace | 6.4 | 12.3 | 0.9 | 57.5 | 5 |
| Aventino | Untreated | Untreated | 10.4 | 33.1 | 3.2 | 49 | 9 |
| Serafino | Flag leaf | Tilt | 8.8 | 24.3 | 2.2 | 60.1 | 8 |
| Serafino | Anthesis | Miravis Ace | 3.2 | 21.0 | 0.8 | 68.8 | 5.5 |
| Serafino | FL + Anth | Tilt fb Miravis Ace | 7.2 | 21.3 | 1.4 | 53.7 | 3 |
| Serafino | Untreated | Untreated | 8.8 | 15.2 | 1.8 | 30.8 | 8 |
| Bono | Flag leaf | Tilt | 5.6 | 14.5 | 1.1 | 23.2 | 4.2 |
| Bono | Anthesis | Miravis Ace | 1.6 | 1.0 | 0.1 | 58.4 | 0.5 |
| Bono | FL + Anth | Tilt fb Miravis Ace | 8.8 | 34.5 | 2.5 | 65.2 | 1 |
| Bono | Untreated | Untreated | 11.2 | 46.7 | 5.2 | 42.2 | 4.5 |
| SH3 | Flag leaf | Tilt | 45.6 | 17.9 | 8.4 | 71.6 | 6.5 |
| SH3 | Anthesis | Miravis Ace | 21.6 | 20.7 | 4.7 | 48 | 6.5 |
| SH3 | FL + Anth | Tilt fb Miravis Ace | 32.0 | 17.3 | 5.6 | 61.5 | 5.5 |
| SH3 | Untreated | Untreated | 44.0 | 23.5 | 10.2 | 60.9 | 6.5 |
| Tayo | Flag leaf | Tilt | 13.6 | 40.4 | 5.0 | 65.1 | 1 |
| Tayo | Anthesis | Miravis Ace | 6.4 | 30.2 | 2.6 | 29.7 | 1.5 |
| Tayo | FL + Anth | Tilt fb Miravis Ace | 3.2 | 17.0 | 0.8 | 31.3 | 2 |
| Tayo | Untreated | Untreated | 6.4 | 19.3 | 1.9 | 22.2 | 0 |
| Receptor | Flag leaf | Tilt | 9.6 | 26.0 | 3.1 | 40.5 | 7 |
| Receptor | Anthesis | Miravis Ace | 6.0 | 26.9 | 1.9 | 62.8 | 2 |
| Receptor | FL + Anth | Tilt fb Miravis Ace | 9.6 | 11.6 | 1.0 | 55.1 | 2 |
| Receptor | Untreated | Untreated | 8.8 | 30.0 | 2.8 | 50.8 | 2 |
| | | ***P > F*** | **0.0001** | **0.0700** | **0.0001** | *0.5355* | *0.0007* |
| | | **LSD 0.05** | **7.9** | **NS** | **2.9** | | |
| | | **LSD 0.10** | **6.6** | **18.8** | **2.4** | *1.68* | *1.71* |
| | | **CV %** | **51.7** | **77.8** | **78.7** | | |

## Table 4. Rye hybrid/variety response to fungicide timing at Princeton, KY, 2022.

| Variety | Fung trt | Fungicide | 5/26/2022 Leaf dis incidence (%) | 5/26/2022 Leaf dis severity (%) | 5/26/2022 FHB incidence (%) | 5/26/2022 FHB severity (%) | 5/26/2022 FHB index (0-100) | Lodging, 0-9 (9=all lodged) | Moisture % | Yield bu/A | Test Weight lb/bu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aventino | Flag leaf | Tilt | 100.0 | 21.0 | 29.0 | 10.5 | 3.1 | 3.0 | 12.0 | 63.9 | 53.0 |
| Aventino | Anthesis | Miravis Ace | 90.0 | 12.5 | 10.0 | 5.4 | 0.7 | 3.5 | 11.9 | 66.2 | 53.7 |
| Aventino | Flag leaf + Anthesis | Tilt fb Miravis Ace | 100.0 | 13.5 | 8.0 | 9.2 | 1.0 | 4.0 | 11.8 | 58.6 | 53.5 |
| Aventino | Untreated | Untreated | 100.0 | 34.8 | 25.0 | 15.3 | 3.5 | 4.8 | 11.8 | 55.4 | 52.3 |
| Serafino | Flag leaf | Tilt | 100.0 | 19.8 | 22.0 | 7.9 | 1.8 | 0.3 | 11.9 | 88.8 | 52.1 |
| Serafino | Anthesis | Miravis Ace | 85.0 | 14.3 | 8.0 | 6.9 | 0.6 | 2.5 | 11.4 | 91.3 | 52.9 |
| Serafino | Flag leaf + Anthesis | Tilt fb Miravis Ace | 90.0 | 9.8 | 11.0 | 6.6 | 0.8 | 2.3 | 11.4 | 91.5 | 53.5 |
| Serafino | Untreated | Untreated | 100.0 | 17.3 | 30.0 | 9.6 | 3.0 | 3.0 | 11.6 | 72.8 | 51.9 |
| Bono | Flag leaf | Tilt | 100.0 | 37.5 | 22.0 | 15.3 | 2.4 | 6.0 | 11.2 | 57.5 | 50.5 |
| Bono | Anthesis | Miravis Ace | 100.0 | 11.3 | 7.0 | 16.9 | 1.3 | 6.5 | 11.6 | 51.1 | 50.5 |
| Bono | Flag leaf + Anthesis | Tilt fb Miravis Ace | 95.0 | 22.3 | 5.0 | 2.5 | 0.3 | 7.3 | 11.7 | 62.4 | 51.1 |
| Bono | Untreated | Untreated | 100.0 | 31.5 | 26.0 | 14.4 | 3.8 | 4.5 | 11.8 | 50.9 | 49.6 |
| SH3 | Flag leaf | Tilt | 100.0 | 28.5 | 51.0 | 20.1 | 10.4 | 0.0 | 11.9 | 56.8 | 51.0 |
| SH3 | Anthesis | Miravis Ace | 90.0 | 39.8 | 19.0 | 11.1 | 2.5 | 0.0 | 11.6 | 83.3 | 52.0 |
| SH3 | Flag leaf + Anthesis | Tilt fb Miravis Ace | 90.0 | 40.0 | 18.0 | 11.0 | 2.2 | 0.0 | 11.6 | 65.5 | 52.0 |
| SH3 | Untreated | Untreated | 95.0 | 33.3 | 49.0 | 15.9 | 8.1 | 0.0 | 11.8 | 60.1 | 50.7 |
| Tayo | Flag leaf | Tilt | 100.0 | 38.5 | 23.0 | 11.2 | 2.9 | 0.0 | 11.7 | 87.7 | 51.0 |
| Tayo | Anthesis | Miravis Ace | 85.0 | 12.0 | 9.0 | 6.5 | 0.8 | 0.0 | 11.7 | 86.5 | 51.9 |
| Tayo | Flag leaf + Anthesis | Tilt fb Miravis Ace | 95.0 | 15.0 | 10.0 | 9.8 | 1.0 | 1.0 | 11.6 | 77.2 | 51.9 |
| Tayo | Untreated | Untreated | 100.0 | 15.0 | 32.0 | 9.7 | 3.1 | 0.0 | 11.6 | 74.9 | 50.5 |
| Receptor | Flag leaf | Tilt | 100.0 | 19.3 | 10.0 | 11.0 | 1.3 | 2.0 | 11.4 | 65.6 | 51.3 |
| Receptor | Anthesis | Miravis Ace | 95.0 | 9.8 | 8.0 | 6.3 | 0.5 | 2.8 | 11.6 | 57.8 | 51.7 |
| Receptor | Flag leaf + Anthesis | Tilt fb Miravis Ace | 100.0 | 12.0 | 2.0 | 2.5 | 0.1 | 1.8 | 11.8 | 89.1 | 51.4 |
| Receptor | Untreated | Untreated | 100.0 | 18.0 | 10.0 | 8.1 | 0.9 | 1.8 | 11.7 | 77.9 | 50.9 |
|  |  | ***P > F*** | **0.4746** | **0.0038** | **0.0001** | **0.0130** | **0.0001** | **0.0001** | **0.0592** | **0.0001** | **0.0001** |
|  |  | **LSD 0.05** | **NS** | **20.4** | **11.5** | **8.9** | **2.1** | **2.7** | **NS** | **20.7** | **1.2** |
|  |  | **LSD 0.10** | **NS** | **17.0** | **9.6** | **7.4** | **1.8** | **2.2** | **0.3** | **17.3** | **1.0** |
|  |  | **CV %** | **10.3** | **62.8** | **44.0** | **61.4** | **63.8** | **78.6** | **2.4** | **20.6** | **1.6** |

## FINAL OBSERVATIONS

The results at Lexington are confounded with lodging and freeze damage. The results suggest that rye did not respond differently to the nitrogen rates and sulfur rates applied. At Princeton, yields on the Crider soil were acceptable. Rye did not respond to fertilizer treatments at either location. Thus, 20 pounds of sulfur per acre was just as effective at producing rye yields as 75 pounds of N per acre in this season.

Rye roots are extensive. Rye needs nitrogen to produce grain yield. The yield responses suggest that rye obtained sufficient nitrogen from the soil profile and did not need additional fertilizer N at this site this season. We observed excellent grain yields with no nitrogen fertilizer in the 2021 harvest season at Lexington and Princeton. Perhaps we are missing measuring rye's ability to capture plant available nitrogen from the soil profile.

For reference, the 2021 rye report is linked here:
https://wheatscience.ca.uky.edu/files/2021_chad_lee_hybrid_rye_management_report_final_rr_0.pdf

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