Kentucky Field Crops News

Spanning 5 departments and 120 counties

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

UK Wheat Science Group
UK Corn & Soybean Science Group

In This Issue

Endangered Species Act – How Will it Affect You in the Near Future?

Dr. Travis Legleiter, UK Extension Weed Specialist

The Endangered Species Act (ESA) has existed since 1973 and was implemented to ensure that any actions taken by a government agency did not jeopardize any species that are federally listed as threatened or endangered. So, why are we now talking about this law in 2025, nearly fifty years after its original passing? The EPA (Environmental Protection Agency) as a federal agency is responsible for regulating pesticide use, which can affect animals and plants or their habitats. Due to this the EPA has a responsibility to consult with the U.S. Fish and wildlife Service and/or the National Marine Fisheries Service to ensure its actions (registration of pesticides) do not jeopardize any threatened or endangered species or their habitats. As one might imagine, this is a complex process and the EPA had not been fulling completing the consultation process for past pesticide registrations. This has left many pesticides vulnerable to lawsuits that have resulted in a few pesticides being pulled from the market. In response, the EPA has spent the past half decade developing strategies to ensure all future pesticide registrations are more secure and are complying with ESA. The first strategy to be implemented in August 2024 was the "*Herbicide Strategy to Reduce Exposure of Federally Listed Endangered and Threatened Species and Designated Critical Habitats from the Use of Conventional Agricultural Herbicides*" or more commonly referred to as the "Herbicide Strategy".

The following list of questions and answers is intended to assist Kentucky growers and applicators in understanding how the strategy will affect herbicide applications in the future. While the strategy looks very complicated on its face, our goal here is to help alleviate some of the complications and show that Kentucky growers can meet the new requirements with minimal, or in many cases no changes to their current practices. If you would like to see the full 79 page strategy and its many appendix's and supporting documents, you can find them here: https://www.epa.gov/endangered-species/strategy-protect-endangered-species-herbicides

How will this affect the herbicides applications made to your field?

All future herbicide labels receiving a new registration or a registration review (occurs every 15 years) will likely have the following mitigations added to the label:

- Spray Drift Mitigations
- Runoff/erosion Mitigations
- Requirements to check the EPA's Bulletins Live! Two website for further restrictions specific to the herbicide being applied and location of the application

When will the new ESA requirements be implemented?

As is alluded to in the above bullet point, this will not be an instant flip of the switch (no ESA mitigations one day and full mitigations the next). Rather ESA mitigations and restrictions will be added to all new herbicide registrations as they occur and will be added to all existing herbicide labels when those products go through the registration review process that must occur every 15 years. In essence, the mitigations will be rolled out on a label-by-label basis over the next 15 years. The first herbicide to receive the ESA requirements on its label is the newly registered Liberty Ultra. We will use Liberty Ultra as our example in the questions below.

What will the spray drift mitigations look like?

Spray drift mitigations will appear as required downwind buffer distances that must be implemented during application of that herbicide. The distance of these downwind buffers will be different for each product based on the EPA determination of the potential impact that product may have on endangered or threatened species at the population level. Downwind buffer distances for ground applications will range from 0ft to a maximum of 230 ft. The Liberty Ultra label has a downwind buffer distance of 10 ft for ground applications.

These downwind buffers, especially those that occur at the 230ft level, look very arduous, but they do not have to occur completely within the field that is receiving the application. The following areas can be included in the downwind buffer distance if they occur immediately adjacent to the field receiving the application. (*The area descriptions are directly from the EPA Herbicide Strategy*)

a) Agricultural fields, including untreated portions of the treated field;
b) Roads, paved or gravel surfaces, mowed grassy areas adjacent to field, and areas of bare ground from recent plowing or grading that are contiguous with the treated area;
c) Buildings and their perimeters, silos, or other man-made structures with walls and/or roof;
d) Areas maintained as a mitigation measure for runoff/erosion or drift control, such as vegetative filter strips (VFS), field borders, hedgerows, Conservation Reserve Program lands (CRP)1, and other mitigation measures identified by EPA on the mitigation menu;
e) Managed wetlands including constructed wetlands on the farm; and
f) On-farm contained irrigation water resources that are not connected to adjacent water bodies, including on-farm irrigation canals and ditches, water conveyances, managed irrigation/runoff retention basins, and tailwater collection ponds.

Lastly, if these areas are not immediately adjacent to the field in the downwind direction, there are additional measures that can be implemented to reduce the downwind buffer distance. A complete list of potential mitigation measures can be found in Table 8 (Page 37) in the Herbicide Strategy . These mitigations include simple mitigations, some that you are likely already implementing, such as the use of a coarse droplet can reduce the buffer distance by 65 to 75% depending on boom height. Additionally, applying when relative humidity is above 60%, which occurs nearly every day in a KY summer, allows for an additional 10% reduction in buffer distance. These mitigation percentages are cumulative, so in essence if you can find mitigations that add up to 100% you can completely eliminate the downwind buffer for that application.

In the case of Liberty Ultra, the downwind buffer of 10ft for ground applications is very manageable and is an encouraging signal that downwind buffers on future labels are likely to be reasonable and manageable.

What will the runoff/erosion mitigations look like?

Runoff/erosion mitigations will appear on labels as runoff mitigation points that are required for application of the given product. Like spray drift mitigations, the runoff mitigation points needed for a product will be based on the EPA's determination of the likelihood of the product to move in surface runoff or move with soil in an erosion event. The number of runoff/erosion mitigations points on a label will range from 0 to a maximum of 9 points. The Liberty Ultra label requires 3 runoff mitigation points.

Runoff mitigation points can be acquired through a number of practices, many of which Kentucky farmers are already implementing on their fields. A full list of mitigations and the points given for each can be found here: https://www.epa.gov/pesticides/mitigation-menu or in a PDF version: https://www.epa.gov/system/files/documents/2024-10/mitigation-menu-pdf-version.pdf

While this list is extensive and seems complicated, remember that these mitigations are in place to allow for any applicator in any crop across the United States to be able to reasonably meet the mitigation points needed to apply herbicides. Thus, complicated = more options, and more options is to the benefit of famers and applicators.

Here are a few examples of in-field and field-adjacent mitigations (not a complete list of mitigations) and their point values that are relevant to the state of Kentucky and are being implemented already in many fields:

In-Field Mitigations	**Points**
No Tillage	3
Strip Tillage	2
Cover Crops	2 to 3
Field-Adjacent Mitigations	
Grass waterways	2
Vegetative Filter Strips or field borders	1 to 3
Vegetative ditch on the downslope side of the field	1

Additionally, you can get mitigation points for the following:

- If you are tracking mitigation points you receive 1 point
- If you are working with a specialist to implement measures to reduce erosion in your field or are implementing a conservation program on your field you can achieve 1 to 2 points.
- If you implementing mitigation measures from both the in-field and field-adjacent menus you will receive 1 additional point

Lastly, many Kentucky counties receive mitigation relief points based on their determined vulnerability to soil erosion/runoff. See the bullet below for a map of those counties in KY.

If you are not able to achieve the points required with the above in-field and field-adjacent mitigations, there are additional steps that you can take. Such as if you are applying at a rate that is a reduction of the annual maximum or reducing the proportion of the field receiving the application can achieve additional points. Although, as you will see below, I believe most Kentucky farmers will be able to achieve 6 to 9 points without making any changes to their current practices.

As an example, I did a runoff/erosion mitigation calculation for a field at the UKREC:

Practice	**Mitigation Points**
County Mitigation relief points – Caldwell County	2
No tillage (*in-field mitigation*)	3
Grass Waterway (*field-adjacent mitigation*)	2
Mitigation tracking	1
Combination of in-field and field-adjacent mitigations	1
Total	9

In this example I would be able to apply Liberty Ultra (only requires 3 mitigation points) as well as any herbicide in the future that requires the maximum 9 mitigation points.

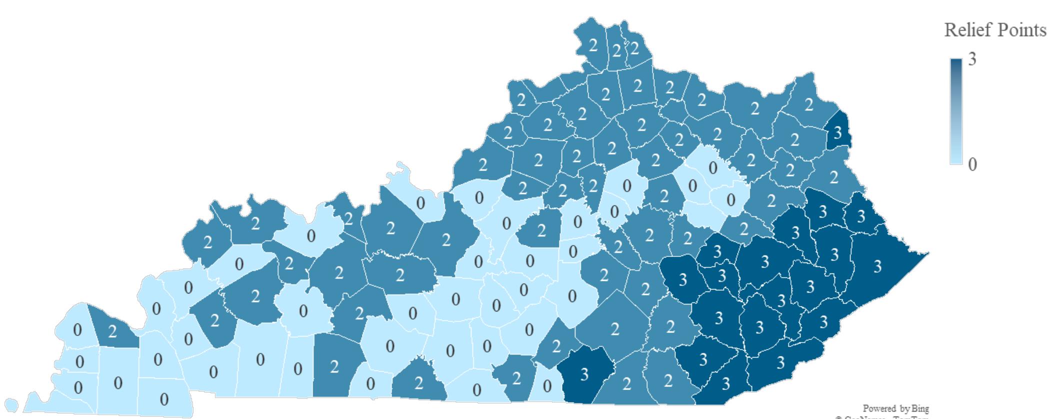
While currently we only have Liberty Ultra with the required runoff/erosion mitigations, a farmer can conduct a calculation on each of their fields now and see if they can reach the maximum 9 points with the practices they are already implementing on their field. Again, I believe that most fields in Kentucky will be able to achieve 6 to 9 mitigation points without implementing any changes to current practices.

Lastly, the EPA has released a handy mitigation calculator that you can use to quickly make your mitigation calculations for each field on your farm.

How many runoff/erosion runoff relief points do Kentucky County's receive?

A complete list of counties in the US can be found here:
https://www.epa.gov/system/files/documents/2024-10/county-mitigation-relief-points-runoff-vulnerability.pdf

Additionally, here is a map of Kentucky with the assigned runoff/erosion mitigation relief points:



Are there any scenarios in which Runoff/Erosion mitigations are NOT required?

Yes, there are scenarios when an applicator does not need to calculate or implement runoff/erosion mitigation measures. You can find a list of these scenarios on the EPA mitigation menu website. I am choosing not to list these in their completeness in this article as most do not apply to Kentucky corn, soybean, and wheat applications/fields. I would still encourage you though to check the EPA mitigation website to make sure these scenarios do not apply to you. Additionally, the mitigation calculator builds in these scenarios and will let you know you can stop the calculation process.

What is Bulletins Live! Two? And should I be using it?

Yes, you should be actively using Bulletins Live! Two. This website indicates if you need to implement any further restrictions, beyond those already on the label, on your particular field for a pesticide application to protect endangered species. The website allows you to zoom in on a map of your field and check to see if there are any PULA's (Pesticide Use Limitation Area) encompassing the field you plan to apply a pesticide to, if so you must follow the additional restrictions listed on the bulletin that the website will provide you. If your field is not within a PULA you can proceed with your application without any further restrictions beyond those on the label. You can check Bulletins Live! Two up to six months prior to your application, thus you can go ahead and check all of your fields now for applications you will make through September of 2025.

Why does compliance matter?

The steps being taken by the EPA and the compliance of applicators ensures that famers and applicators will continue to have reliable access to the herbicides needed to protect crops from weed interference, while also continuing to protect valuable endangered and threatened species.

Citation: Legleiter T., 2025. Endangered Species Act – How will it affect you in the near future? Kentucky Field Crops News, Vol 1, Issue 3. University of Kentucky, March 14, 2025.

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Historical Corn and Soybean Yield Improvement in Kentucky

Dr. Dennis Egli, University of Kentucky

It won't be long before Kentucky farmers start planting the 2025 corn and soybean crops. At this time of the year farmers are always optimistic, expecting record yields if the weather cooperates. This expectation is a result of the yield trends over the last nearly 100 years.

Corn yields in Kentucky trended upward since 1940 (Fig. 1), that's 84 years of steadily increasing yield (ignoring fluctuations due to weather). If one takes the long view, however, increasing yield was not always a given (Fig.1).

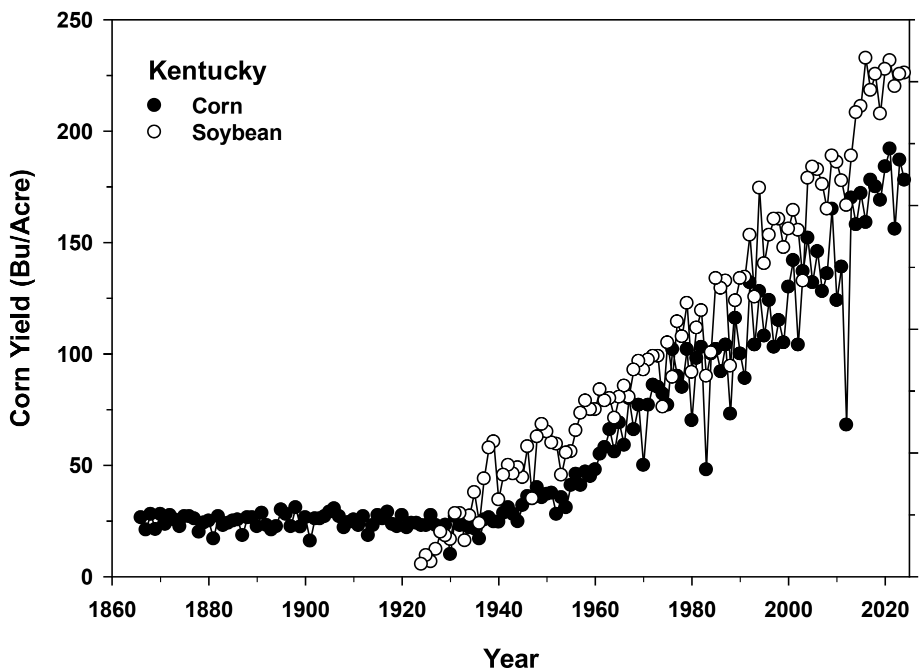

Fig. 1. Kentucky corn and soybean yields. From National Agriculture Statistics

Corn yield did not change from the time of the Civil War (1866) to roughly the beginning of World War II (1940) (Fig. 1). The yield curve during this period was flatter than a pool table, creating a yield plateau that lasted for 74 years. It's hard to imagine a situation where a farmer's corn yield was the same as his father's or even, perhaps, his grandfather's. Now that's a significant plateau! Yield during this period averaged 24.3 bushels pr acre in Kentucky. This plateau was not limited to corn in Kentucky; corn in all the Corn Belt states, wheat in Kentucky and other crops in other countries exhibited similar plateaus.

There was no plateau for soybean (Fig. 1) because it was not grown for grain in the US until the early 1900's and yields were not estimated by the National Agricultural Statistics Service until 1924. Soybean yield trended upward from 1924, when the yield was 11 bushels per acre, until the present. The initial yield increases were probably a result of producers learning how to grow this new crop and selecting better lines from the initial lines introduced from China.

Midwestern agriculture during the plateau period for corn was low-input, obviously sustainable (it lasted for 74 years) and would probably be considered organic by today's standards. Cropping systems were based on rotations including corn, small grains (wheat and oat) and hay. Nitrogen came from animal manure and legumes in the rotation. Weeds were controlled by mechanical cultivation (there were no herbicides), farmers grew open-pollinated corn varieties, saved their own seed and farms were small (< 50 acres).

Animal power was replaced by the internal combustion engine and mechanization replaced hand labor near the end of the plateau. These changes greatly reduced the need for feed production and probably improved the efficiency and timeliness of management operations.

Extension programs in the early 1900's trained farmers to identify the perfect corn ear to save for seed for the next crop. University research focused on soil fertility and other aspects of crop management. Interestingly, none of these activities had any effect on yield and the plateau persisted.

Some cataclysmic change in crop production systems in the 1930's ended the plateau and initiated the period of steady yield growth that continued to the present day. The big question is - what change(s) drove the steady increase in yield?

Open-pollinated varieties were replaced by hybrids (hybrids were planted on nearly 90% of the acres in Kentucky by 1950) which forced farmers to buy their corn seed from commercial companies. The use of inorganic fertilizers increased rapidly after 1945, fueled, in part, by the availability of nitrates from plants that produced explosives during World War II. The development of herbicides and pesticides improved weed, insect and disease control. These inputs were supported by changes in management practices (e.g., higher corn populations, narrow rows – made possible by herbicides and mechanization – and better disease and insect control). Some argue that changes in the environment (e.g., more solar radiation resulting from the clean air act and a cleaner atmosphere) contributed to yield growth. These changes stimulated a dramatic shift from a low- to a high-input system during this period with a big increase in off-farm inputs.

The work of plant breeders was the driving force behind the increase in corn and soybean yields. The changes in inputs and management practices were essential, but they would not be effective without improved higher-yielding hybrids and varieties. You can't manage a 1960s hybrid to produce today's yields and today's hybrids won't produce today's yields with 1960's management. Hybrid (variety) vs. management is the classic interaction – neither can get the job done on their own.

T. R. Malthus, a preacher and economist in England, argued in his 1798 book (An Essay on the Principle of Population), that exponential population growth would always outpace the linear growth in food supplies so that humankind would always live on the ragged edge of starvation. World population in 1798 was roughly 1 billion, now, 226 years later, the population is 8.2 billion and the world faces an obesity epidemic - Malthus was wrong. He did not anticipate the dramatic growth in crop productivity and the area cropped in the high-input era that outpaced population growth to maintain a generally well-fed world. The key to the growth in yield was the efforts of plant breeders that produced improved hybrids (varieties), management practices that allowed them to reach their potential productivity, and an agri-business system that made the necessary inputs readily available to producers.

But what will the future hold? Will yield growth continue in the more hostile environments created by climate change or will it plateau, ultimately proving Malthus correct? I would be optimistic, especially given the declining rate of population growth, if it were not for the looming presence of climate change and societies' apparent unwillingness to do anything about it.

"They are ill discovers that think there is no land when then can see nothing but sea" Francis Bacon, essayist, philosopher and statesman, 1561-1625.

Adapted in part from: Egli, D.B. 2008. Comparison of Corn and Soybean Yields in the United States: Historical Trends and Future Prospects. Agron. J. 100: S-79 – S-88.

Citation: Egli, D., 2025. Historical Corn and Soybean Yield Improvement in Kentucky. Kentucky Field Crops News, Vol 1, Issue 3. University of Kentucky, March 14, 2025.

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Set the Stage for a Successful Growing Season with a Strong Burndown

Dr. Travis Legleiter, UK Extension Weed Scientist

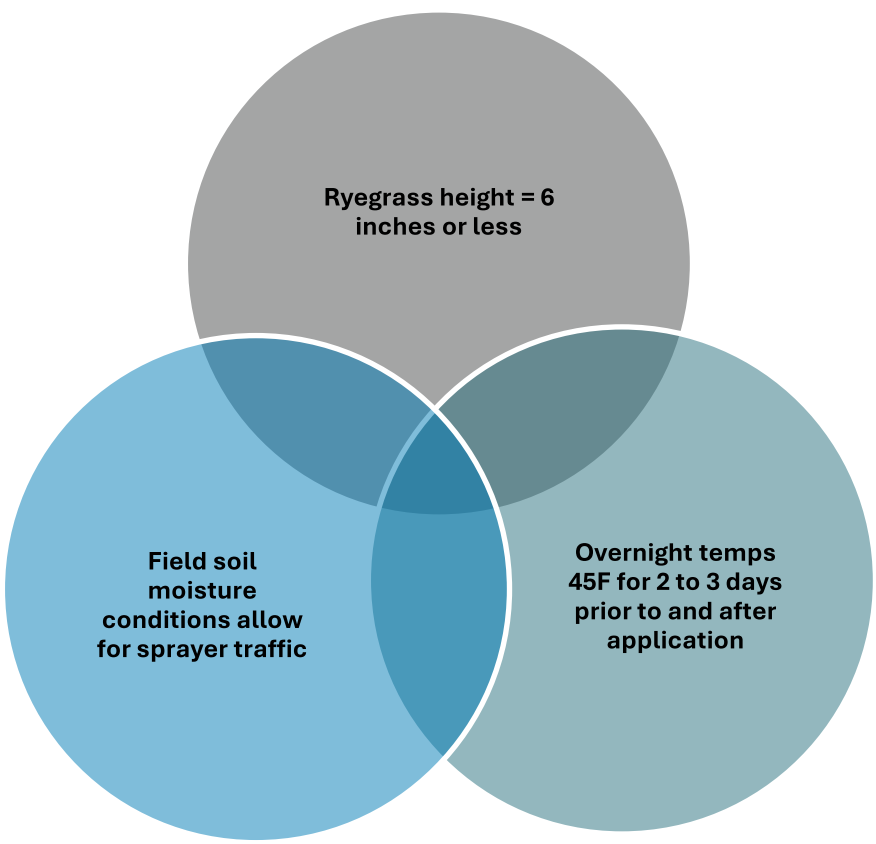
After a miserably wet February with several spells of unusually cold temps, March is finally bringing spring weather. Along with spring weather comes winter annual weed growth and burndown applications will begin in earnest in the very near future. As the sprayers head to the field, here are a few quick reminders and tips to help start the growing season with a successful herbicide burndown.

Italian Ryegrass Demands Special Attention

Italian Ryegrass (aka annual ryegrass) is an increasing issue on Kentucky corn and soybean acres with failed burndowns increasing every year across the state.

Annual ryegrass is one of the first weeds to green up in late winter and is already taking advantage of the increasing temperatures. One essential key for a successful annual ryegrass burndown is making applications within the window of the three conditions outlined in Figure 1.

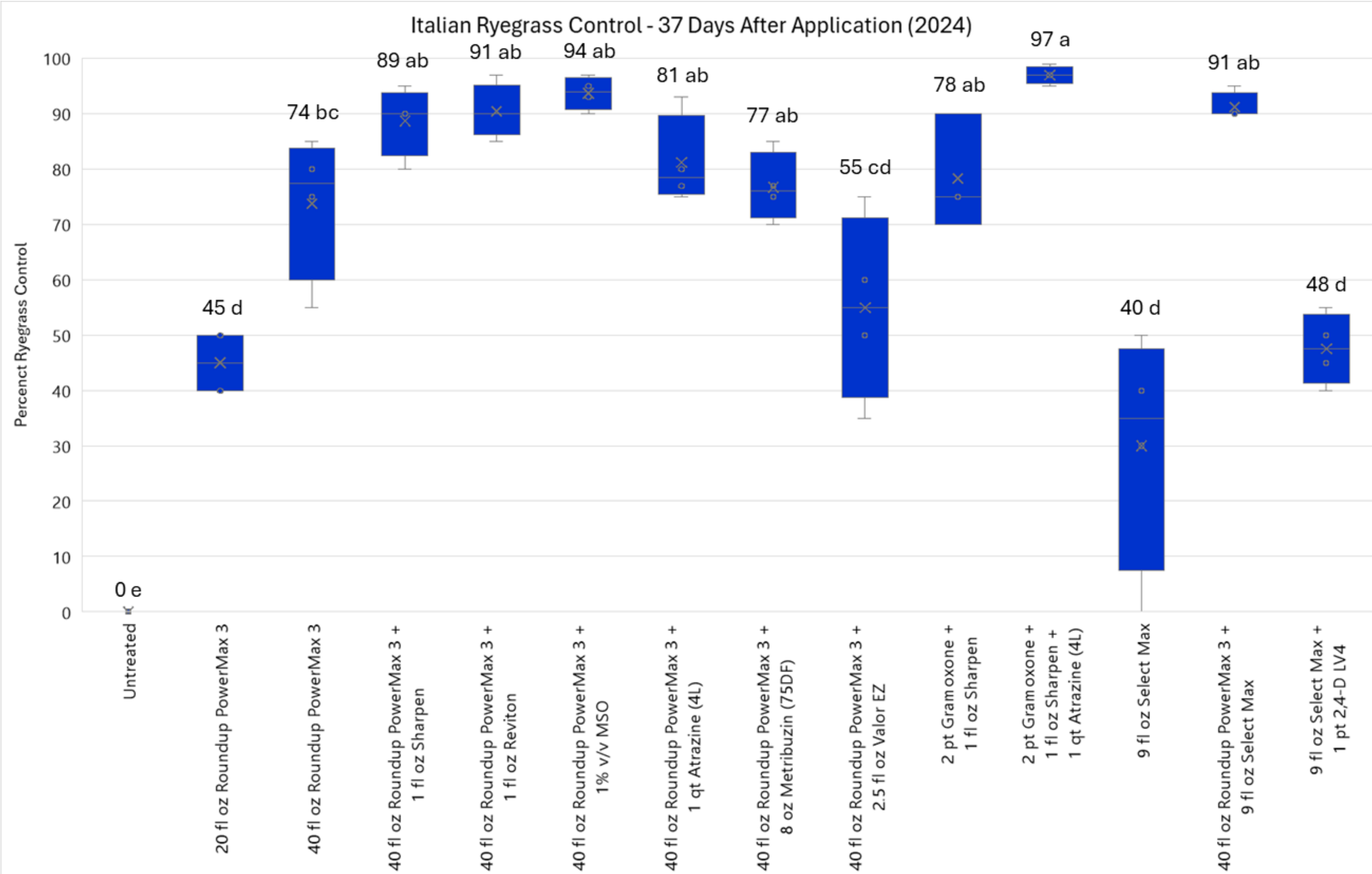
Figure 1. The optimal window for Italian (annual) ryegrass burndown occurs when all three of these parameters occur at the same time.



Unfortunately, capturing this window of the correct growth stage, air temperatures, and soil conditions can be almost impossible in most Kentucky springs. With the understanding that we may not be able to capture this magical window on every acre, we must focus on maximizing our burndown applications in other ways. We have found based on our research that the following keys are essential to maximizing the burndown of Italian ryegrass (See Figure 2 for further data from our 2024 spring burndown trial):

- **Use at least 1.5lb ae/a glyphosate (40 fl oz Roundup PowerMax 3)**
    - This has been shown In UK weed science research numerous times and is the single biggest mistake I find when a failure occurs. Ryegrass burndown applications are NOT the place to cut rates when looking to cut inputs
    - There is a handy chart on page 17 of AGR-6 (https://publications.ca.uky.edu/sites/publications.ca.uky.edu/files/AGR6_0.pdf) where you can find the rate of your specific glyphosate product that is equivalent to 1.5 lb ae/a.
- **The addition of 1 fl oz Sharpen (or 15 fl oz Verdict) to 1.5 lb ae glyphosate results in the consistently greatest ryegrass control in our research.**
    - Our research in 2024 found preliminary results that the inclusion of MSO as an adjuvant in this tank mix may be the leading contributor to the increased consistency in ryegrass control. We are actively conducting a second year of research to confirm these findings.
- **Avoid tank mixing atrazine or metribuzin with glyphosate and as these products will antagonize glyphosate activity on ryegrass**
- **The best non-glyphosate mixture is Gramoxone plus atrazine or metribuzin plus 2,4-D or dicamba.**
    - Paraquat (Gramoxone) and atrazine or metribuzin are synergistic and increase control as compared to each of the components applied alone. The addition of 2,4-D or dicamba is optional for those fields where troublesome broadleaves like marestail (horseweed) exist.
    - These tank mixtures work best on small ryegrass and under warm sunny conditions. A follow up application to capture any regrowth should be planned.
- **Avoid the use of Select Max (clethodim) or other group 1 herbicides**
    - The group 1 herbicides (clethodim, quizalofop, sethoxadim, etc) work very slowly in comparison to other systemic herbicides when the weather is warm. When you spray these products in the spring when temperatures are cool, especially overnight, this only exacerbates the slow activity and ryegrass almost always escapes application of the group 1 herbicides.
    - We have heard of a few applicators using low rates of Select Max (2 to 3 fl oz/a) with glyphosate and have observed increased control over glyphosate alone. We always discourage the use of reduced rates of herbicides, as this is a known pathway to herbicide resistance. Additionally, I suspect that the increased activity has less to do with active ingredient (clethodim) and more to do with the EC or 'oily' formulation that is acting as an adjuvant similar to the MSO mentioned above.

Figure 2. Visual control of Italian ryegrass thirty-seven days after burndown application.



Pay Attention to the Wind

March is bringing a welcome increase in temperatures that will allow for successful spring applications, unfortunately the warmer temperatures are typically accompanied with high winds which are not favorable for spray applications. Each year I receive numerous calls from specialty crop growers, homeowners, and fellow grain crop farmers with complaints of drift from spring burndown applications. Typically, we are including either growth regulators (2,4-D or dicamba) and/or contact herbicides such as saflufenacil in our burndowns which can cause significant off-target injury at very low rates. As the warm temperatures and calendar give us all spring fever and the urge "to do something in the field" be aware of wind conditions and avoid the costly mistake of drifting onto a neighbor.

Adjuvants

Make sure you understand what adjuvants are needed to assure your herbicide applications are effective. Adjuvants are often needed to ensure the product can effectively find its way into the weed and to its target site of action. The exclusion of an adjuvant such as MSO from a Sharpen application can be the difference in a successful and a failed burndown. You can either refer to the herbicide label or AGR-6 (http://www2.ca.uky.edu/agcomm/pubs/agr/agr6/agr6.pdf) for recommended or required adjuvants for the products you plan to apply. Additionally, if you would like more information on the importance of adjuvants in herbicide applications, refer to this CPN Publication: Adjuvants with Herbicides: When and Why They are Needed (https://cropprotectionnetwork.org/publications/adjuvants-with-herbicides-when-and-why-they-are-needed)

Carriers

Last year, we received a few questions about the use of liquid nitrogen as a carrier for spring burndown applications. While the inclusion of a small amount of nitrogen (such as ammonium sulfate) can be beneficial in getting herbicides into plants, larger amounts such as liquid N as a carrier may have the opposite effect. Liquid nitrogen can cause rapid plant tissue necrosis and antagonize the movement of a systemic herbicide to its target site of action allowing weeds to survive the herbicide application.

We would recommend to use water as your burndown carrier for the most effective herbicide applications. Although all water is not created equally, and we must be aware of the properties of the water we use for herbicide applications. As we start a new growing season it may be wise to go ahead and check your water sources' pH and hardness. Adjustment of water hardness and pH can be critical for successful herbicide applications throughout the season. In the challenging conditions of spring burndowns having a quality water carrier can go a long way.

Citation: Legleiter, T., 2025. Set the Stage for a Successful Growing Season with a Strong Burndown. Kentucky Field Crops News, Vol 1, Issue 3. University of Kentucky, March 14, 2025.

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Italian Ryegrass Control Field Tour Slated for March 27

For a second consecutive year, the University of Kentucky will host the Italian Ryegrass Control Field Tour. Presented by Dr. Travis Legleiter, UK Extension Associate Professor - Weed Science, this year's tour will take place Thursday, March 27, 2025. The day will begin at 9 a.m. CDT with introductory remarks at the Caldwell County Extension Office, located at 1025 U.S. Hwy. 62 W. in Princeton. A caravan will then proceed to the University of Kentucky Research and Education Center in Princeton to tour ryegrass research plots. Topics will cover ryegrass control in the fall and spring prior to no-till corn and soybean planting as well as continued research on ryegrass control in wheat. The field tour will conclude by 11:30 a.m.

"The battle against Italian ryegrass is increasing in the Commonwealth every year with more cases of failed ryegrass burndowns occurring each spring. We are continually looking for better options for gaining an advantage on this troublesome weed and are excited to showcase some of our findings so far at the 2025 Italian ryegrass Field Tour," Legleiter said.

Once categorized as solely a problem in wheat, Italian ryegrass has increasingly become problematic in all of Kentucky's major agronomic crops, now affecting no-till corn and soybean acres. Italian ryegrass (aka annual ryegrass) is one of the most problematic weed species globally with over 75 unique cases of herbicide resistance reported across the world. If allowed to compete with corn, Italian ryegrass can reduce yields up to 60%. Options for Kentucky farmers to control this weed prior to corn and soybean planting will be discussed.

Presented by Dr. Travis Legleiter, UK Extension Associate Professor - Weed Science, this field tour will highlight the options available to Kentucky farmers for maximum control of this problematic weed in the fall and spring prior to corn and soybean planting.

Educational credits for CCA include 3 CEUs in IPM. Kentucky Pesticide Applicator Credits include 3 CEUs for Category 1A (Ag Plant).
Register at https://uky.az1.qualtrics.com/jfe/form/SV_2c6KX2NmiqEp1TE

For more information about the 2025 Italian Ryegrass Control Field Tour call (859) 562-2569 or email jason.travis@uky.edu.

Biological N Fixation Products for Corn: An Update

Dr. John Grove, UK Soil Researcher and Dr. Chad Lee, UK Grain Crops Specialist

Replacing, economically, some or all of corn's fertilizer nitrogen (N) need with biological N fixation (BNF) is becoming a major goal in commercial corn production. With BNF, microbes fix atmospheric N as ammoniacal N and provide additional N nutrition to the crop. Several BNF products have reached the marketplace and questions regarding their efficacy are rising. Field research evaluating these products is ongoing. This article is intended to review the work that we and some others have done.

Just to our north, in Illinois, field research at 2 sites over 3 years (total of 4 site-years). These authors (Woodward et al., 2025), after averaging their data across the site-years, found that the BNF product, PROVEN 40™ (Pivot Bio), significantly raised yield by 1.8 bu/acre, regardless of the applied N rate, which ranged from 0 to 200 lb N/acre. The grain yield N response was quite positive, averaging 106.1 bu/acre at 0 lb N/acre and 186 bu/acre at 200 lb N/acre (Table 1, right side). These results, on average, indicate that the benefit to the biological product was unrelated to crop N status, whether clearly deficient or entirely sufficient.

When one digs into the supporting information provided with this report (Woodward et al., 2025, suppmat), a more detailed picture emerges (Table 1). At all four site-years corn gave large, positive responses to fertilizer N addition. Only one site-year (Champaign, 2019), the lowest yielding site-year, exhibited a significant positive yield response to the BNF product (+4.6 bu/acre). There was a significant interaction between BNF and N rate on yield for the Champaign, 2020 site-year, where, depending upon the N rate, BNF addition resulted in both lower and higher yield relative to the yield in the absence of BNF. The authors did not explain why they chose to ignore the lack of a positive yield response to the BNF for 3 of 4 site-years and then averaged that response over all 4 site-years of data.

Table 1. Four site-years of corn grain yield from N rate by BNF§ studies near Champaign and Nashville, Illinois.

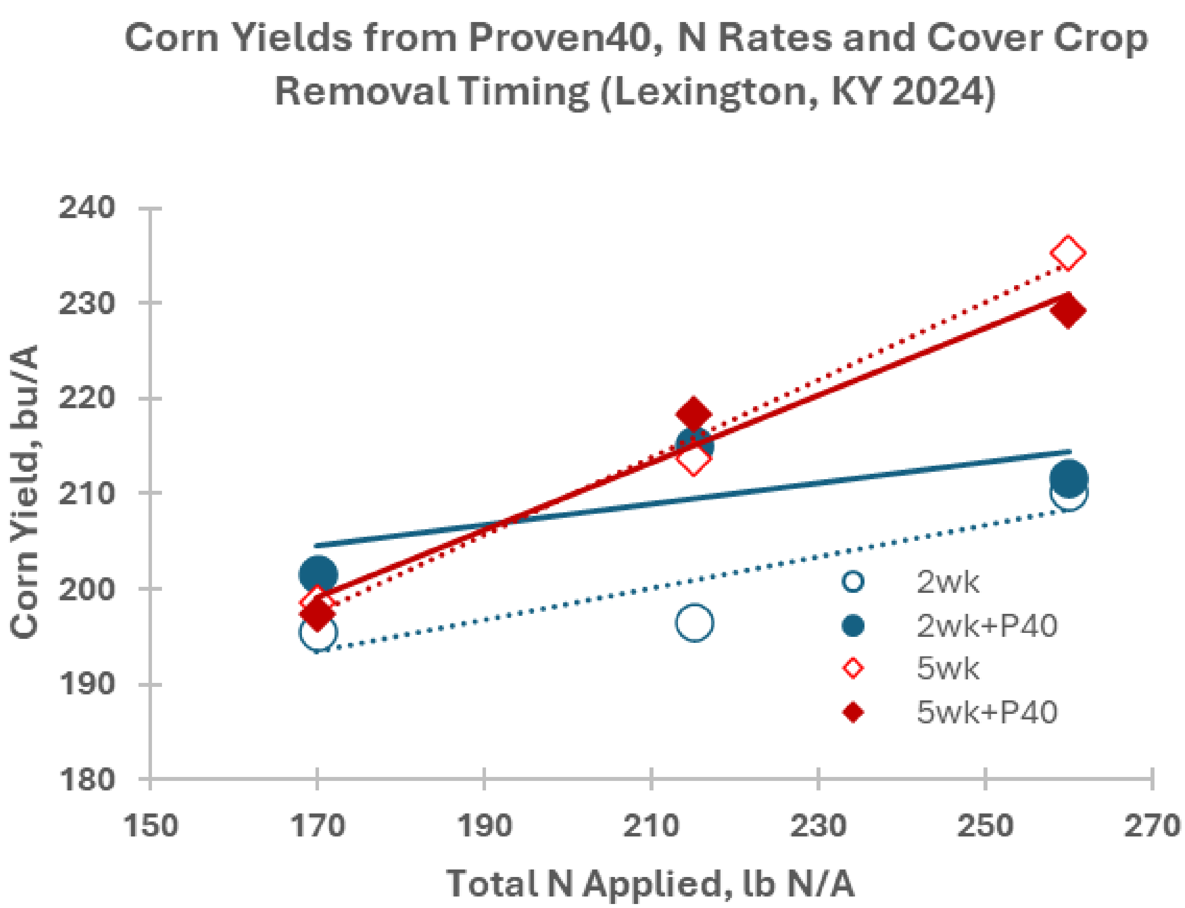
	Champaign, 2019			Champaign, 2020			Champaign, 2021			Nashville, 2021			4 Site-Year Ave.		
fertilizer N rate	no BNF	with BNF	N rate ave.	no BNF	with BNF	N rate ave.	no BNF	with BNF	N rate ave.	no BNF	with BNF	N rate ave.	no BNF	with BNF	N rate ave.
lb N/acre	bu/acre														
0	57.8	59.9	58.9e	104.7	103.7	104.2e	130.0	132.1	131.0e	132.9	130.5	131.7d	106.4	106.6	106.5e
40	71.0	73.8	72.4d	116.3	119.0	117.6d	166.8	167.9	167.3d	163.9	166.9	165.4c	129.5	131.9	130.7d
80	83.0	95.1	89.0c	130.9b	137.2a	134.0c	192.4	193.1	192.7c	189.6	185.6	187.6b	148.9	152.8	150.9c
120	119.2	130.3	124.7b	151.5a	145.1b	148.3b	217.9	218.4	218.2b	193.7	197.7	195.7ab	170.6	173.0	171.8b
200	152.0	147.3	149.7a	162.2	158.3	160.3a	229.3	234.8	232.0a	200.7	203.3	202.0a	186.1	186.2	186.1a
BNF ave.	96.5b	101.3a		133.2	132.7		187.2	189.2		176.3	176.8		148.3b	150.1a	

*Within any one column or any one row, yield values followed by the same letter are not significantly different at the 90% level of confidence.

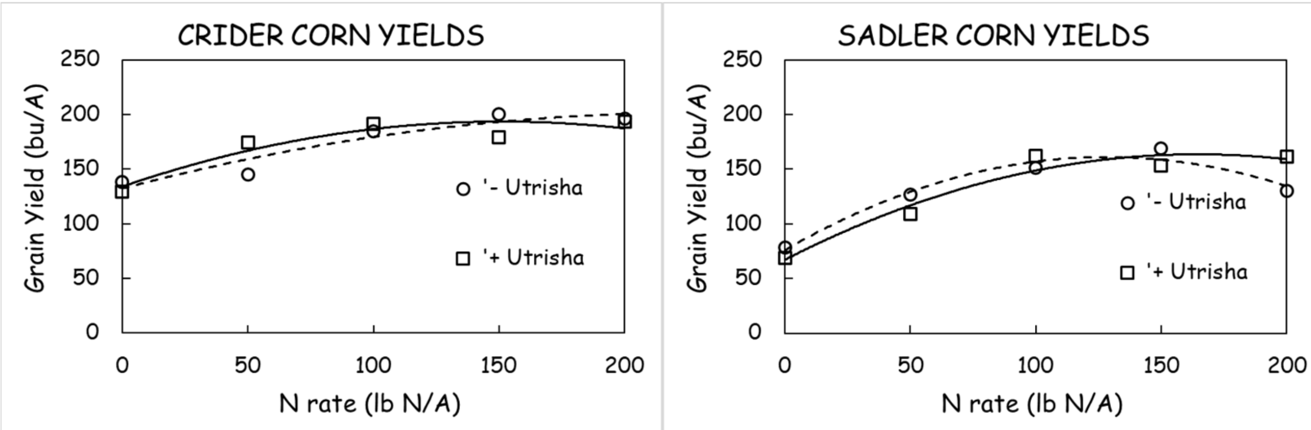
§BNF = PROVEN 40™

Here in Kentucky, Chad has also looked at PROVEN 40™ BNF product use in no-till corn that was planted into a heavy cereal rye cover crop (Nalley and Lee, 2024). In the first year, 2023, the treatments consisted of two N rates, 140 and 180 lb N/acre, both without and with the BNF product. As was observed in Illinois, there was no interaction between the N rate and the use of PROVEN 40 ™ on corn grain yield. The 140 and 180 lb N/acre rates averaged 199 and 191 bu/acre, respectively, and were not significantly different, statistically. Corn yields with PROVEN 40 ™, at both N rates, averaged 200 bu/acre and were 9 bu/acre better than N applied without the BNF. This difference was statistically significant. Again, the positive impact due to the biological product was not related to the applied N rate. There was speculation that the in-furrow BNF product was beneficial because the decomposing rye cover crop was having a negative impact on corn N nutrition across both fertilizer N rates.

In 2024, Chad's no-till corn followed rye killed either five or two weeks before planting (Lee et al., 2025), resulting in different levels of decomposing rye residue at planting. Three N rates (170, 215 and 260 lb N/acre) were applied, both without and with PROVEN 40™. In the figure below, the lower amount of rye residue resulting from the cover crop kill five weeks before planting improved corn yield response to the higher N rate treatments, but there was no impact of PROVEN 40™. With the heavier rye residues from killing the cover crop only 2 weeks before planting, there was a trend for greater yield with use of PROVEN 40™, regardless of N rate, though the positive yield difference was only statistically significant at 215 lb N/acre. Again, the results indicated that the BNF improved crop yield but not crop N nutrition.



John evaluated the BNF Utrisha N™ (Corteva) in 2022 on two soils (Crider, Sadler) and at each of five fertilizer N rates (0, 50, 100, 150 and 200 lb N/acre). In the figures below one can see there was a good corn yield response to fertilizer N rate but no consistent response to the BNF, even at the lower N rates where some benefit to a BNF product might be expected.



A general lack of corn yield response to BNF products has been widely observed. In the North Central region, 61 site-years of field work with corn, spring wheat, sugar beet and canola, in 10 states, resulted in only two site-years where a positive yield benefit to a BNF product was found. More important than the lack of yield benefit to the use of BNF products is that we cannot predict where or when a BNF product might work, and with a lower probability of benefit, that predictability is critical to grower success with these products. The potential benefit to BNF use in the presence of heavy cover crop biomass decomposition is an interesting possibility and worthy of further investigation.

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Tariffs and Trade: The Cost to U.S. Agriculture

Dr. Grant Gardner, UK Extension Economist

Tariffs are a government tool used to raise the price of foreign products, encouraging consumers to buy domestically produced goods. They serve multiple purposes, including protecting local industries from foreign competition, generating government revenue, and responding to unfair trade practices. This article examines the US export portfolio for corn, soybeans, and wheat, highlighting key countries where retaliatory tariffs could lead to price volatility and losses in agricultural commodities.

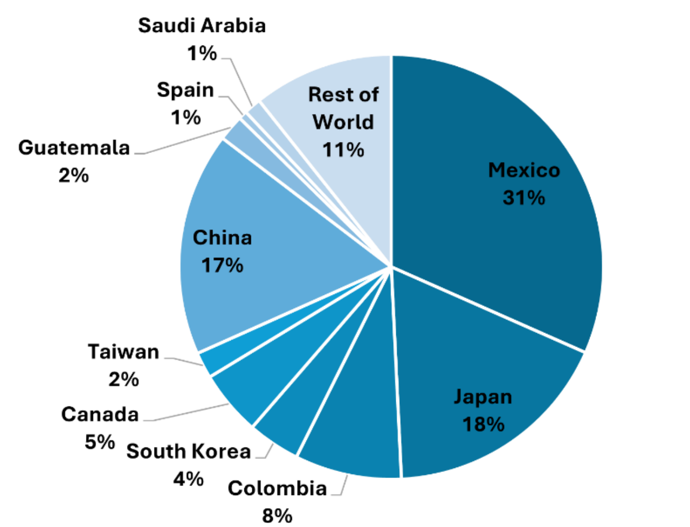

Figure 1: Average US Corn Exports by Destination (2020-2024), Source: Data Source: U.S. Census

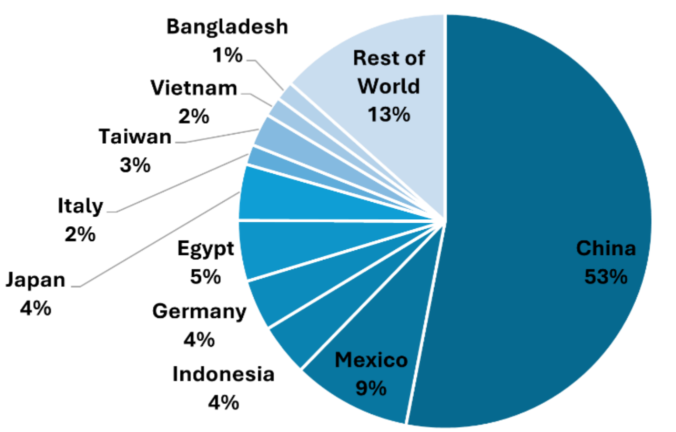

Figure 2: Average US Soybean Exports by Destination (2020-2024), Source: Data Source: U.S. Census

While tariffs may seem beneficial by offering protection, generating revenue, or as a negotiating tool for broader policy issues, they create winners and losers. When the US imposes tariffs, other countries often retaliate, targeting industries reliant on exports. In many cases, US agriculture bears the brunt of these actions.

As of March 15, the US has enacted tariffs on Canada, Mexico, China, and the European Union—nations that collectively purchase nearly 54% of US corn exports, 62% of soybean exports, and 24% of wheat exports (2020–2024 average). Additional tariffs have been proposed against Japan, which accounts for 18% of US corn exports, 4% of soybean exports, and 10% of wheat exports. As retaliatory tariffs take effect, US commodities become more expensive internationally which

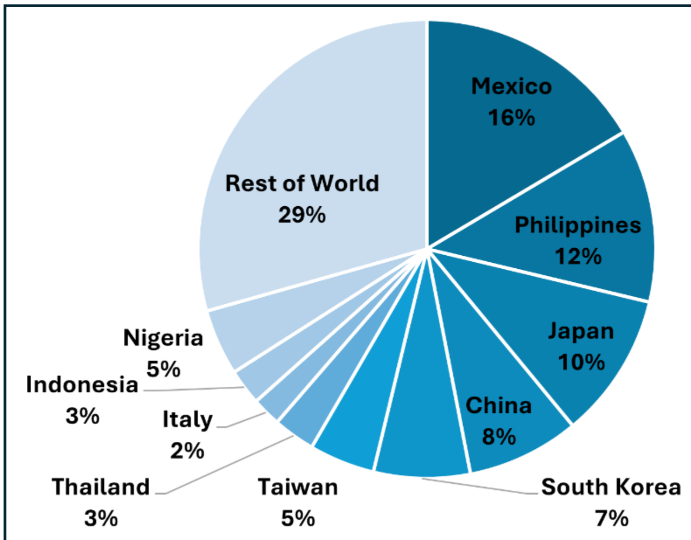

Figure 3: Average US Wheat Exports by Destination (2020-2024), Source: Data Source: U.S. Census

reduces exports and increases domestic supplies, which in turn drives domestic prices down. While these countries may not stop purchasing US crops entirely, they are likely to shift demand toward competing suppliers such as Brazil, Argentina, and the Black Sea region.

Regardless of political perspective, tariffs disrupt free trade, undermining comparative advantage and efficiency. For example, the US holds a comparative advantage in corn production relative to Canada, while Canada holds a comparative advantage in potash production. When tariffs are imposed, the domestic supply of efficiently produced US corn rises, pushing US prices lower. Meanwhile, retaliatory tariffs restrict access to efficiently produced Canadian goods, such as potash, causing their US prices to increase.

While tariffs may provide short-term benefits to certain industries and could serve long-term policy goals, their immediate impact on US agriculture is overwhelmingly negative.

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2025 Corn and Soybean Fungicide Efficacy Guides Now Available

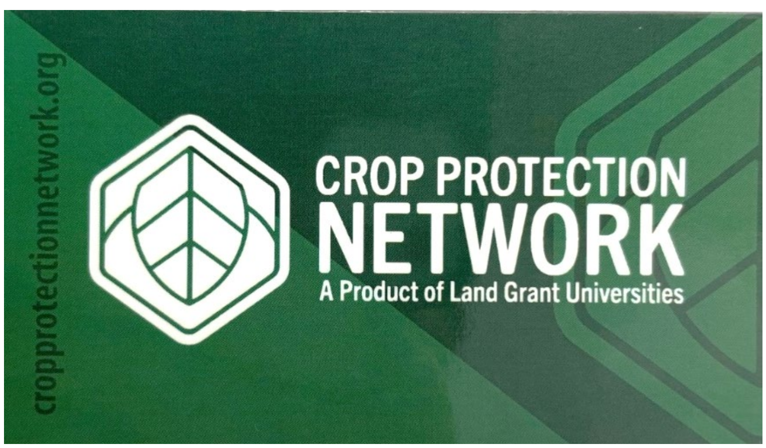
Dr. Kiersten Wise, UK Extension Plant Pathologist & Dr. Carl Bradley, UK Extension Plant Pathology

The 2025 fungicide efficacy tables for foliar diseases of corn and soybean, and for soybean seedling diseases have been updated, and are now available through the Crop Protection Network website: https://cropprotectionnetwork.org/ .

These tables are updated annually based on data provided by United States Extension plant pathologists, with efficacy determined through replicated research trials across a broad geographic area. Results from University of Kentucky research trials are included in the development of these national fungicide efficacy ratings.

The ratings in these guides reflect the efficacy of a fungicide against a given disease and are not rating yield response to a fungicide. It is an applicator's legal responsibility to read and follow label directions. Updated tables include:

- **Fungicide Efficacy for Control of Corn Diseases**
- **Fungicide Efficacy for Control of Soybean Seedling Diseases**
- **Fungicide Efficacy for Control of Soybean Foliar Diseases**



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Early Planted Soybean Does Benefit from Good Soil Fertility

Dr. John Grove, UK Soil Research/Extension

I've been reading in both popular and scientific press that for soybean fields with low fertility, early planting substitutes for addition of needed soil-based nutrition (Allen, 2025, Loman et al., 2024). The implication was that low fertility fields intended for soybean production and that remain unfertilized are less vulnerable to nutrient deficiencies if these fields are planted early. This observation flies in the face of other work, both earlier and ongoing, that I'm aware of.

In 1983, Peaslee and co-workers published field research on the interaction of soil potassium (K) nutrition and soybean planting date (Peaslee et al., 1983). Three levels of soil test K had been established in these long-term plots; 144, 204 and 429 lb/acre – considered low, medium and very high, respectively, by the ammonium acetate extraction test used in Kentucky at that time. Table 1, below, shows the soybean yield responses that were found. The soil test level designations are like those we use today. The soybean planting date range is later than those now used by Kentucky soybean producers. That said, please note the strong positive interaction between earlier planting and soil K nutrition. The total yield spread is 53 - 31 = 22 bu/acre, and though early planting contributes most to that yield spread, soil K nutrition isn't far behind.

Table 1. Soybean yield response to planting date and soil K nutrition (Peaslee et al., 1983).

Planting Date	Soil Test K Level Low	Medium	Very High	Response to K nutrition
	----------soybean yield, bu/acre----------			
May 27	40	47	53	13
June 16	40	44	46	6
July 8	31	36	37	6
Response to Planting Date	9	11	16	

I've also been following the sulfur (S) work of Dr. Shaun Casteel, at Purdue (Casteel, 2023). He's been looking at the soybean-S nutrition yield response as related to planting date. Between 2018 and 2022, Dr. Casteel compared the yield response to S nutrition between mid-May and early June planting dates, about 3 weeks apart (Table 2). The soybean yield response to added S was 8.2 bu/acre with mid-May planting dates and only 2.3 bu/acre with early June planting dates. In 2023, Dr. Casteel expanded the number of planting dates to three, 18 April, 12 May, and 7 June. The response to S addition was 20.2, 14.6, and 3.0 bu/acre, respectively (Table 3).

Table 2. Soybean yield response to planting date and N, S or N + S fertilizers (adapted from Casteel, 2023)

Nutrient Treatment	Nutrient Source(s)	Early Planting 11-14 May	Late Planting 5-10 June
		--yield (bu/acre)--	
no N no S	none	63.8	58.6
only N	urea	65.9	60.6
only S	gypsum	73.1	62.2
N + S =	AMS	72.9	61.6
average of	ATS		
3 tmts	gyp+urea		

Table 3. Soybean yield response to planting date and N, S or N + S fertilizers (adapted from Casteel, 2023)

Nutrient	Nutrient	2023 Planting Date		
Treatment	Source(s)	18 April	12 May	7 June
		---------yield (bu/acre)---------		
no N no S	none	77.5	75.4	66.6
only N	urea	80.9	77.8	68.4
only S	gypsum	98.9	90.5	69.0
N + S =	AMS	99.9	91.8	72.0
average of	gyp+urea			
2 tmts				

Loman et al. (2024) measured soybean yield in 133 fields between 2014 and 2021, trying to find "which and how well soil test values predict yield of unfertilized soybean". The relationship between yield and planting date was also reasonably good and they then 'binned' the data by planting date. The planting dates were first divided into Early (2 April-23 May) and Late (24 May-11 June) groups. Then, a Very Early (2 April-9 May) data subset was split off the Early dataset and a Very Late (5 June-11 June) subset was split off the Late set of data.

For each planting date bin, they looked at relationships between soil fertility parameters and soybean yield and reported that soil fertility was more important to yield in later planted soybean than earlier planted. This caused them to recommend later planted soybean in high fertility fields and early planted soybean in fields with lower fertility to reduce overall fertilizer needs.

At first glance, it was clear that the Late/Very Late yield data were indeed much more affected by one or more of the soil test parameters, while the Early/Very Early yield data were much less influenced (Loman et al., 2024). But when I dug into the supplemental material (Loman et al., 2024, suppmat) provided with this paper I found some indications that might explain why these authors report results very different from those of Peaslee et al. (1983) and Casteel (2023).

Table 4 gives soil test parameter (soil organic matter, soil pH, soil test phosphorus and potassium) for the Very Early (n=38) and Very Late fields (n=34), as taken from Loman et al. (2024. suppmat). The first indication that some of the Very Late fields might be less fertile than the Very Early fields is in the soil organic matter (SOM) data; both minimum and first quartile values are considerably lower in the Very Late subset. There was also a lower minimum pH value in the Very Late subset, but this might not make much of a difference to the overall analysis.

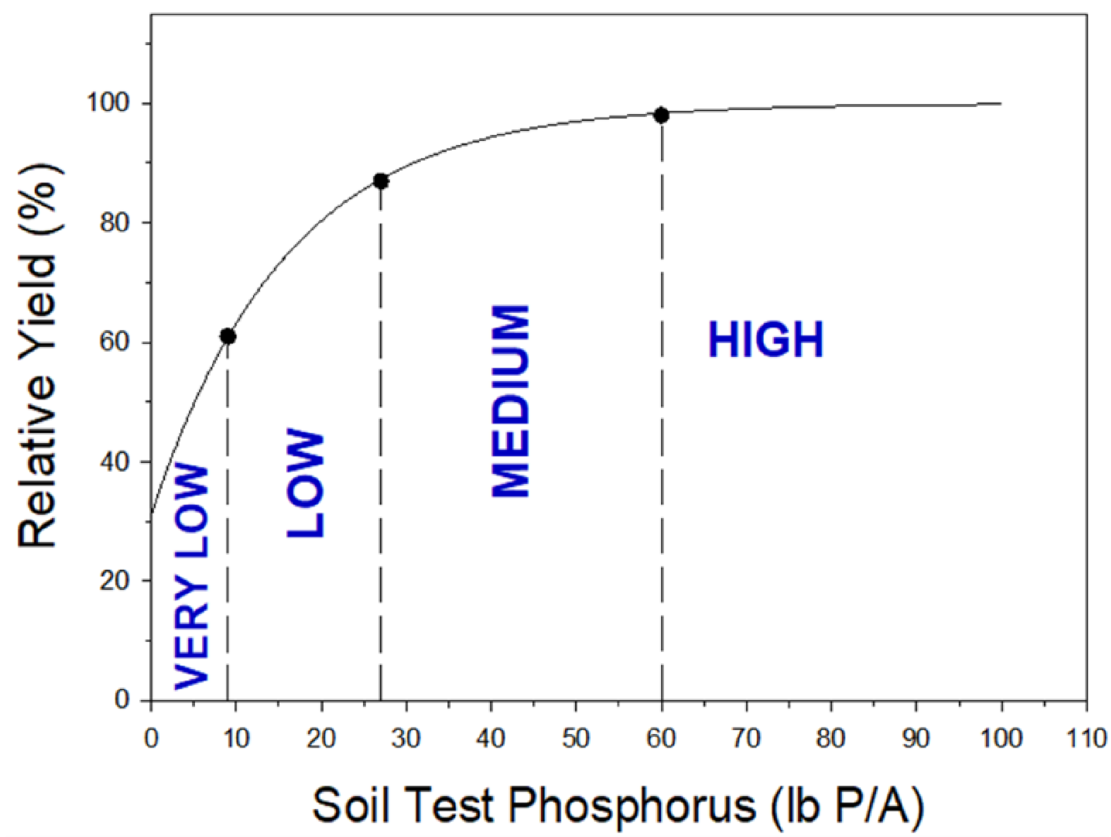
The more important indications that the population of Very Early fields were generally more fertile than the Very Late fields were in the Table 4 soil test phosphorus (STP) and potassium (STK) data. In AGR-1 (Ritchey and McGrath, 2022), the minimum and first quartile values for Very Early field STP, 44 and 56 lb/acre, are considered medium-high to high. Those same values for Very Early field STK, 182 and 230 lb/acre, are considered medium-low to medium for soil K supply to the crop. Very Late fields exhibited much lower minimum and first quartile values for STP and STK (Table 4). The values here are comparable to AGR-1 values because the UK soil test labs also use the Mehlich 3 extraction procedure to measure STP and STK.

Table 4. Soil test parameter data from Loman et al. (2024. suppmat).

		Soil Test Parameter Values				
Planting Date Bin	Soil Test Parameter	Minimum Value	First[1] Quartile	Mean	Third[2] Quartile	Maximum Value
Very Early	SOM (%)[3]	2.0	2.9	3.9	4.6	7.1
Very Late	SOM (%)	1.8	2.0	3.6	5.5	6.4
Very Early	water pH	5.5	5.9	6.5	7.0	7.3
Very Late	water pH	5.2	5.9	6.3	6.7	7.0
Very Early	STP (lb/a)[4]	44	56	84	100	166
Very Late	STP (lb/a)	24	42	96	112	296
Very Early	STK (lb/a)[5]	182	230	286	326	496
Very Late	STK (lb/a)	110	174	266	296	590

[1]Parameter value under which 25% of values are found when arranged in increasing order.
[2]Parameter value under which 75% of values are found when arranged in increasing order.
[3]Soil organic matter, in percentage by weight.
[4]Mehlich 3 extractable soil test phosphorus (P), in pounds per acre.
[5]Mehlich 3 extractable soil test potassium (K), in pounds per acre.

The implications of these differences in the two data subsets are evident when one considers the general relationship between grain crop yield and soil test nutrient levels (Figure 1). Crop yield responsiveness falls dramatically as soil test values rise - the Law of Diminishing Returns (Figure 1). As the Very Early planting date data subset contains no very low or low STP or STK values, then there would be much less chance, with that data subset, that yields from these unfertilized Very Early planting date fields would show a relationship with soil fertility – all the fields in this data population were already fertile enough – no low fertility fields in the data subset. The Very Late data subset included fields with very low to low soil fertility levels, and not surprisingly that data subset exhibited a relationship between soybean yield and soil fertility. The conclusions of Loman et al. (2024) are not well supported when you consider that these two data subsets are not equally 'representative' as regards having an equivalent range in soil fertility levels for the sampled fields.



The more obvious conclusion is that soybean field soil fertility matters, regardless of soybean planting date. Fields that are low in soil fertility need lime and fertilizer, not earlier planting – which is not a substitute for good soybean nutrition. And there are soil nutrients (K, S) which the existing data suggest are especially important when planting soybean early.

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Analysis What drives Yield in the last 6 Years of the Corn Yield Contest

Dr. Mohammad Shamim, UK Grain Crops Extension Associate and
Dr. Chad Lee, UK Grain Crops Specialist

The Kentucky Corn Yield Contest is organized jointly by the University of Kentucky and the Kentucky Corn Growers Association. The yield contest can provide valuable insights into the highest-yielding corn fields across the state. A single year of the contest is subject to unusual events of the year, such as 2024 where some areas of the state had adequate rainfall and other areas suffered from drought. We chose to analyze the last six years of the contest. By analyzing contest entries from 2019 to 2024, we can identify key management practices that potentially contribute to top-tier yields.

We carefully examined management strategies alongside meteorological data, including rainfall, temperature, and solar radiation. With yield contest data, we cannot compare a single change in one practice and how it affects yield. However, we can run a more complex or holistic approach where we analyze how both management practices and weather conditions influence yield. With this approach we were able to analyze all production practices provided by the farmers on each entry form.

When analyzing the effects of management practices only, planting population emerged as the primary driver of yield differences in the contest. Farmers who targeted seeding rates between 35,000 and 37,500 plants per acre achieved a significantly higher median yield—approximately 20 bushels per acre more than those who planted at lower seeding rates (Figure 1). Interestingly, increasing seeding rates beyond 37,500 plants per acre did not result in further yield gains.

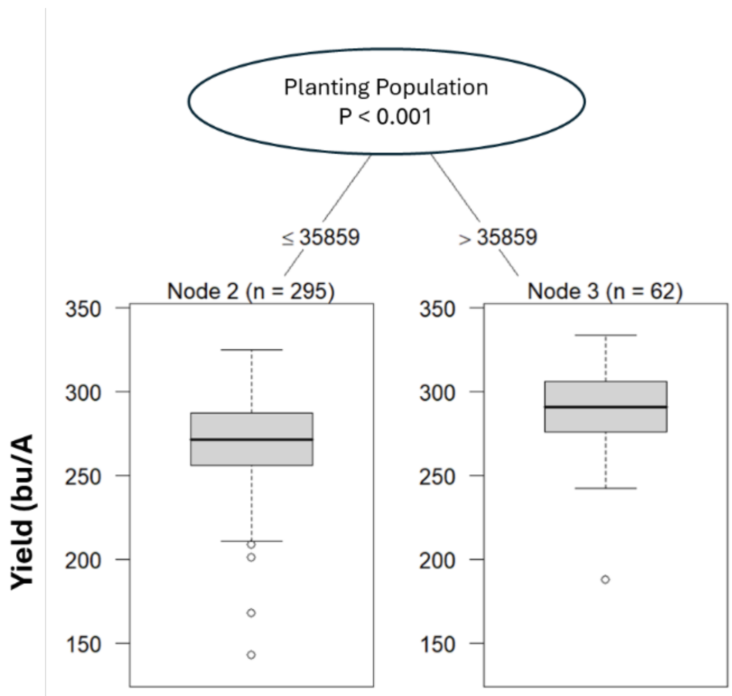

Figure 1: Conditional inference analysis reveals planting population to be key in determining yield variability in corn yield contest. In this analysis, corn populations above 35,859 plants per acre had higher yields. The graph displays box and whisker plots. Each box contains 50% of the data observed. The solid line in the middle of the box is the median yield. The median is just the middle value between all yields listed high to low. The dots are outliers. Generally, a smaller box suggests less variability. In this example, the box and median are both higher for the scenario on the right (the higher plant population).

In the second scenario, the effects of only meteorological variables were taken into consideration. Solar radiation and precipitation appeared to drive corn yield in some interesting ways. When average daily solar radiation in August was below 24.64 w/m^2, the total solar radiation in July became the dominant factor influencing yield. If July's solar radiation exceeded 21.6 w/m^2, the median yield was significantly higher than when radiation levels were lower. However, when August solar radiation exceeded 24.64 w/m^2, April precipitation became a key factor influencing yield. In this scenario, higher April rainfall was associated with lower median yields compared to drier conditions (Figure 2).

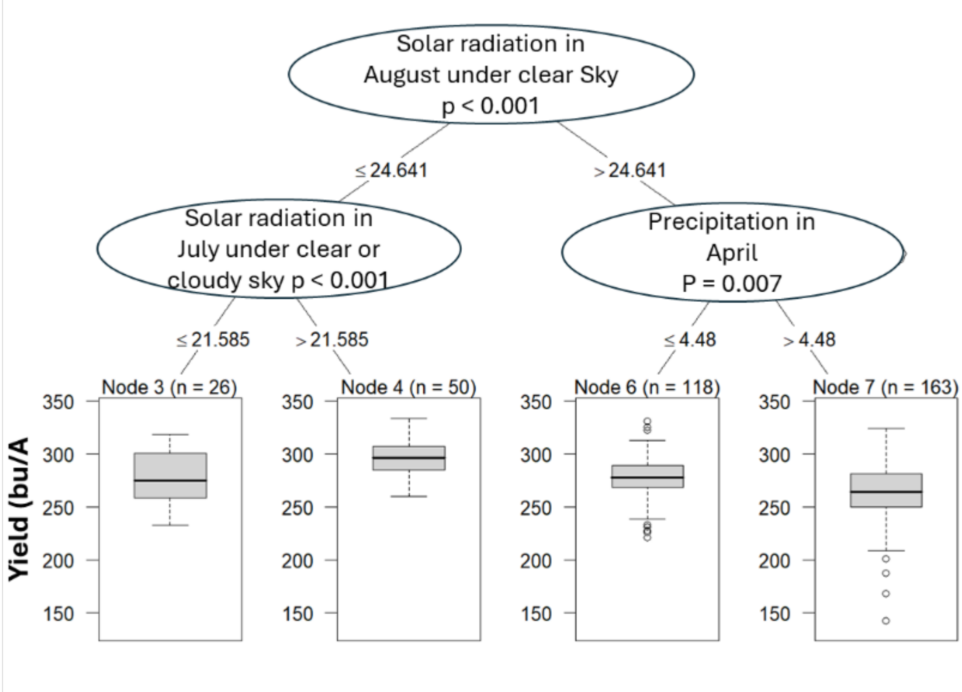

Figure 2: The effect of meteorological conditions on corn yield in the corn yield contest as indicated by a conditional inference tree analysis. The first separator was solar radiation in August. If solar radiation in August was less than 24.642 w/m2, then July solar radiation above 21.585 w/m2 increased corn yields. If solar radiation in August was above 24.642 w/m2, then precipitation in April below 4.48 inches increased corn yields.

Lastly, when analyzing the combined effect of management practices and meteorological conditions, the weather-related patterns remained consistent. However, in years when April precipitation exceeded 4.48 inches, harvest population played a critical role in mitigating yield losses. Fields with a harvest population above 33,500 plants per acre had better yields compared to those with lower plant populations (Figure 3).

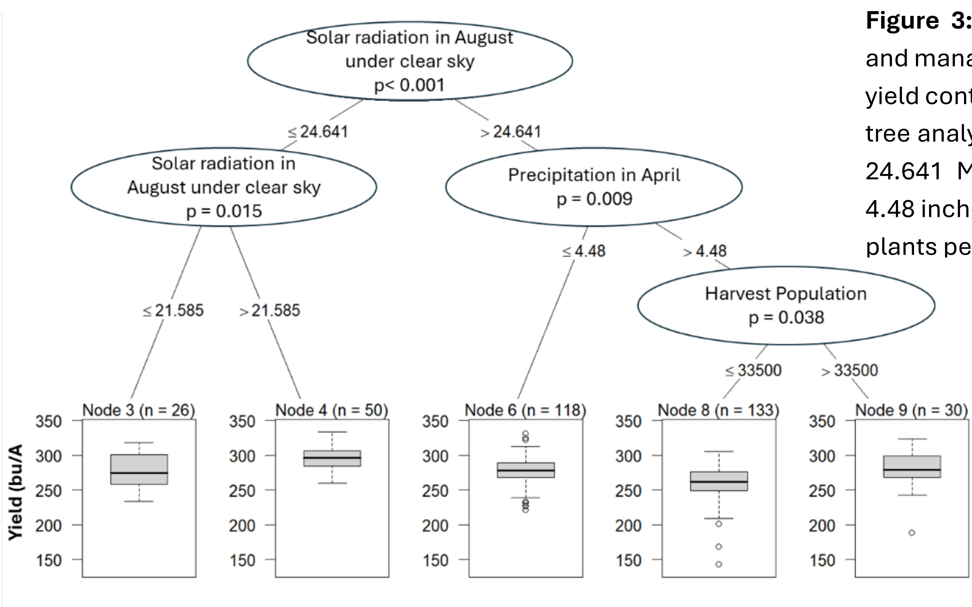

Figure 3: The effect of meteorological conditions and management practices on corn yield in the corn yield contest as indicated by a conditional inference tree analysis. If solar radiation in August was above 24.641 MJ/m2 and April precipitation was above 4.48 inches, then harvest populations above 33,500 plants per acre had the highest yields.

What all of this means

Lower solar radiation in August suggests increased cloud cover and sufficient rainfall. In years when August had fewer sunny days, total solar radiation (both under clear and cloudy skies) in July became a key factor driving yield. This suggests that July provided enough light to support photosynthesis, but frequent cloud cover could have also meant periodic rainfall, creating an ideal balance of moisture and radiation. The best yields were achieved when August was not excessively dry and July had both adequate solar radiation and frequent showers, ensuring optimal photosynthesis and grain fill.

On the other hand, when August had higher solar radiation under clear skies, it likely meant fewer cloudy days and potential drought stress. In such cases, early planting (in April) allowed corn to progress through critical growth stages before the onset of late-season drought. However, if April had excessive rainfall, delaying planting until May, then a harvest population above 33,500 plants per acre helped mitigate yield losses.

This analysis would suggest that if a farmer is delayed until May to plant corn because of a wet April, corn populations should be increased to ensure sufficient ear production to maintain yield.

Citation: Shamim, M.J., Lee, C., 2025. Analysis What drives Yield in the last 6 Years of the Corn Yield Contest. K*entucky Field Crops News, Vol 1, Issue 3.* University of Kentucky, March 14, 2025.

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Grain Crop Phosphate and Potash Rate Recommendations: AGR-1 Updates

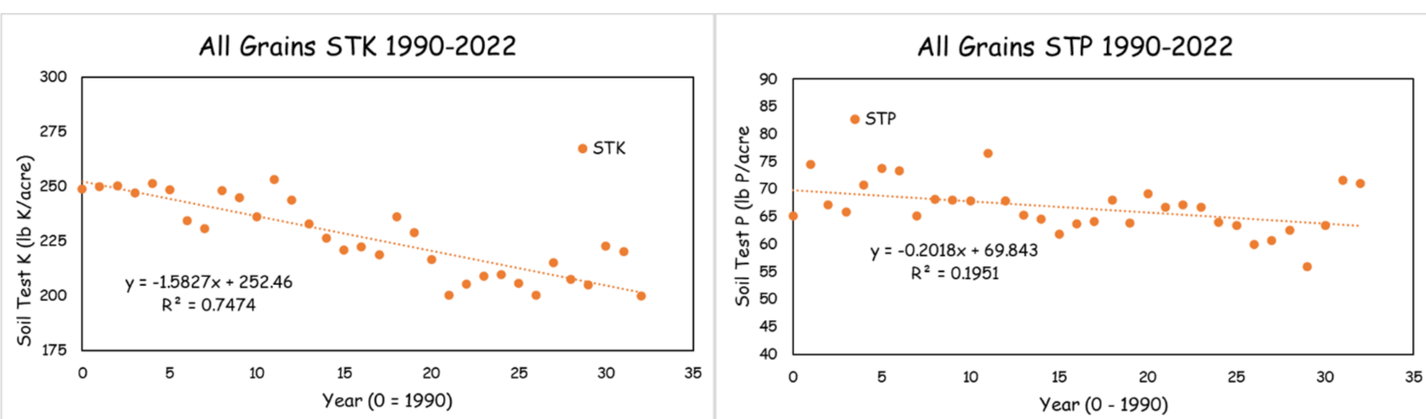
Dr. John Grove, UK Soil Specialist and Edwin Ritchey, UK Extension Soil Specialist

Grain crop fertilizer phosphate (P_2O_5) and potash (K_2O) maintenance rate recommendations in AGR-1 (Ritchey and McGrath, 2020) have not been reexamined since their inception - 1992. Other UK extension faculty (G. Schwab, pers. comm.; B. Lee, pers. comm.) have reported that soil test phosphorus (P) and potassium (K) levels were declining in Kentucky row-crop acres, even when AGR-1 (Ritchey and McGrath, 2020) fertilizer P_2O_5 and K_2O rate recommendations are followed. This analysis was caused by those observations. The declines imply either that: a) there has been an expansion in row crop acreage to areas with lower initial soil test P and K levels; or b) that P_2O_5 and K_2O row crop maintenance rate recommendations are not adequate.

First, there was a need to verify soil test P (STP) and/or K (STK) changes with time. The UK soil test lab provided STP and STK data for the 1990 to 2022 period. The data was sorted according to the commodity to be fertilized, as noted on the sample submission sheet, and then by year. Corn, soybean, and winter small grain (barley, canola, oat, rye, wheat) soil test data were separated from other soil test information. There was considerable fluctuation in annual sample numbers, but the average annual sample number was around 9300.

Across all grain commodities, STK has declined over the entire period (Figure 1a). The annual STK mean values were determined using all values remaining after removal of individual STK values greater than one standard deviation above the mean - to remove samples from manured fields or soils naturally high in STK. The portion of samples removed each year ranged from 9.6 to 15.7%, averaging 12.4%. Using the remaining samples, average annual STK values fell about 1.6 lb STK per acre per year. Over the past three decades, STK has fallen by about 47 lb STK per acre.

Figure 1. Annual average: a) soil test K (STK); and b) soil test P (STP) values from soils intended for grain production – 1990-2022.



Across the grains, STP has also declined (Figure 1b) over the time period. As was done for STK, the annual STP mean values were determined using all values remaining after removal of individual STP values greater than one standard deviation above the mean - to remove samples coming from manured fields or soils naturally high in STP. The portion of samples removed, per year, ranged from 7.1 to 12.4%, averaging 9.8%. The decline was modest, about 0.2 lb STP per acre per year. Over 33 years, STP has fallen by 7 lb STP per acre across this group of samples. For University of Kentucky (UK) soil test lab users, STP and STK have been falling for several decades.

After a close look at the soil test data for corn and soybean, there was little support for the idea that soybean area expansion into less fertile fields caused the temporal decline in STP and STK values. This does not preclude the fact that recent expansion in both corn and soybean acreage has contributed to some decline in STP and STK values, but the amount of that contribution was not easy to separate.

It was known that STP and STK declines might be related to increasing grain yield, and coincidently greater grain P and K removal. Kentucky's annual average corn, wheat, and soybean grain yield data for 1980 to 2022 were gathered from the National Agricultural Statistics Service (NASS, 2023). Because grain P and K removal are the product of grain yield and grain P and K concentrations, we also needed to update our grain P and K concentration data. A recently published analysis of corn, soybean and wheat grain P and K composition, from the nearby state of Illinois (Villamil et al. 2019), was used (Table 1). The existing AGR-1 grain composition data (Ritchey and McGrath, 2020) was at least 25 years old. Comparing the grain P and K concentrations, recent corn and wheat grain values are lower, while recent soybean grain values are higher (Table 1).

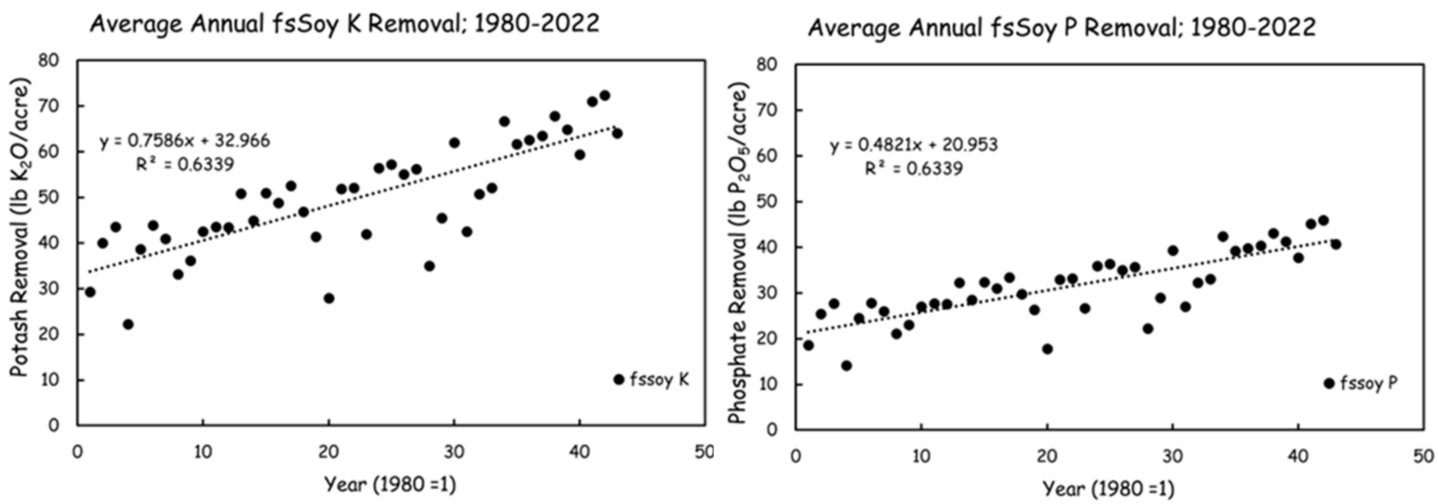
Table 1. Corn, soybean and wheat grain P and K concentrations.

	---------- Grain P ----------		---------- Grain K ----------	
Grain Crop	AGR-1*	Illinois**	AGR-1*	Illinois**
	-------- lb P_2O_5/bu --------		-------- lb K_2O/bu --------	
corn	0.40	0.37	0.35	0.24
soybean	0.70	0.75	1.10	1.18
wheat	0.50	0.46	0.30	0.28

* Ritchey and McGrath, 2020; ** Villamil et al. 2019.

The annual yield data from NASS was combined with the recent grain P and K concentration data to estimate annual average P and K removal for corn, full-season soybean, wheat and double-crop soybean. As an example, Figure 2 illustrates how rising full-season soybean yield was driving grain P and K removal.

Figure 2. Average annual full-season soybean: a) potash; and b) phosphate removal – 1980-2022.



Current AGR-1 grain crop P_2O_5 and K_2O rate recommendations are shown in the three tables that constitute Figure 3. The maintenance portion of the recommendations is contained in the red boxes within each table. The Mehlich III STP and STK values are in lb per acre.

Figure 3. Current AGR-1 grain crop phosphate and potash rate recommendation tables, showing maintenance recommendation rates and associated soil test values bounded by red boxes.

Table 13. Phosphate and potash recommendations (lb/A), corn.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
Very high			>420	0
High	>60	0	355 - 420	0
			336 - 354	0
			318 - 335	0
			301 - 317	0
Medium	46 - 60	30	282 - 300	30
	41 - 45	40	264 - 281	30
	37 - 40	50	242 - 263	30
	33 - 36	60	226 - 241	40
	28 - 32	70	209 - 225	50
			191 - 208	60
Low	23 - 27	80	173 - 190	70
	19 - 22	90	155 - 172	80
	14 - 18	100	136 - 154	90
	9 - 13	110	118 - 135	100
	6 - 8	120	100 - 117	110
Very low	1 - 5	200	<100	120

Table 18. Phosphate and potash recommendations (lb/A), small grains.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
High	>60	0	>300	0
Medium	48 - 60	30	213 - 300	30
	45 - 47	40	187 - 212	40
	41 - 44	50		
	38 - 40	60		
	34 - 37	70		
	31 - 33	80		
Low	24 - 30	90	159 - 186	50
	17 - 23	100	132 - 158	60
	10 - 16	110	104 - 131	70
Very low	<10	120	<104	80

Table 15. Phosphate and potash recommendations (lb/A), soybean.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
High	>60	0	>300	0
Medium	40 - 60	30	242 - 300	30
	34 - 39	40	226 - 241	40
	28 - 33	50	209 - 225	50
			191 - 208	60
Low	22 - 27	60	173 - 190	70
	16 - 21	70	155 - 172	80
	11 - 15	80	136 - 154	90
	9 - 10	90	118 - 135	100
	7 - 8	100	100 - 117	110
	6	110		
Very low	1 - 5	120	82 - 99	120
			64 - 81	130

The new grain crop P_2O_5 and K_2O rate recommendations are shown in the three tables contained in Figure 4. The expanded maintenance portion of the recommendations is contained in the green boxes within each table. As in Figure 3, Mehlich III STP and STK values are in lb/acre. Note that there is no proposed change to the Mehlich III STP and STK values at which no fertilizer P_2O_5 or K_2O are recommended (60 lb STP/acre and 300 lb STK/acre, respectively). The recommended fertilizer P_2O_5 and K_2O rates for STP and STK values below those associated with the newly expanded maintenance P_2O_5 and K_2O rates also remain unchanged.

Figure 4. New AGR-1 grain crop phosphate and potash rate recommendation tables, showing maintenance recommendation rates and associated soil test values bounded by green boxes.

Table 13. Phosphate and potash recommendations (lb/A), corn.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
Very high			>420	0
High	>60	0	355 - 420	0
			336 - 354	0
			318 - 335	0
			301 - 317	0
Medium	46 - 60	50	282 - 300	50
	41 - 45	50	264 - 281	50
	37 - 40	50	242 - 263	50
	33 - 36	60	226 - 241	50
	28 - 32	70	209 - 225	50
			191 - 208	60
Low	23 - 27	80	173 - 190	70
	19 - 22	90	155 - 172	80
	14 - 18	100	136 - 154	90
	9 - 13	110	118 - 135	100
	6 - 8	120	100 - 117	110
Very low	1 - 5	200	<100	120

Table 18. Phosphate and potash recommendations (lb/A), small grains.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
High	>60	0	>300	0
Medium	48 - 60	40	213 - 300	40
	45 - 47	40	187 - 212	40
	41 - 44	50		
	38 - 40	60		
	34 - 37	70		
	31 - 33	80		
Low	24 - 30	90	159 - 186	50
	17 - 23	100	132 - 158	60
	10 - 16	110	104 - 131	70
Very low	<10	120	<104	80

Table 15. Phosphate and potash recommendations (lb/A), soybean.

Category	Test Result: P	P_2O_5 Needed	Test Result: K	K_2O Needed
High	>60	0	>300	0
Medium	40 - 60	40	242 - 300	60
	34 - 39	40	226 - 241	60
	28 - 33	50	209 - 225	60
			191 - 208	60
Low	22 - 27	60	173 - 190	70
	16 - 21	70	155 - 172	80
	11 - 15	80	136 - 154	90
	9 - 10	90	118 - 135	100
	7 - 8	100	100 - 117	110
	6	110		
Very low	1 - 5	120	82 - 99	120
			64 - 81	130

Adjusting for modern grain P and K concentrations and increasing yield-driven nutrient removal, we raised corn, soybean and wheat fertilizer P_2O_5 or K_2O maintenance rates by 10 to 20 lb P_2O_5 and 10 to 30 lb K_2O per acre, depending on the individual crop.

A maintenance fertilizer rate recommendation is intended to 'maintain' a level of soil-based nutrition that minimizes the possibility of nutrient deficiency. This kind of 'insurance' recommendation does not imply that there is a good probability of an economic benefit to the fertilizer recommendation in the year of application. Grant Thomas (pers. comm.) wrote: "The soil bank account does not pay interest. In fact, losses to fixation, erosion, etc. cause negative interest. Chemical and biological uncertainty make the soil fertilizer bank much less valuable than those dollars left in a bank. Doses of needed fertilizer are more efficient than doses of maintenance fertilizer." In certain situations, careful and annual soil testing can better ensure adequate, and more economical, soil-based nutrition.

Some challenges remain. There is a need for grain composition data on other important winter crops, including canola, barley and rye. Continuing yield growth with time necessitates ongoing review of crop P and K removal values every 5 to 10 years.

McGrath, J, and E. Ritchey. 2022. 2020-2021 Lime and Nutrient Recommendations, AGR-1. Univ. Kentucky Coop. Extn. Svc., Lexington, KY.

National Agricultural Statistics Service (NASS). 2023. Data and Statistics. Quick Stats. USDA. Washington, D.C. https://www.nass.usda.gov/Statistics_by_State/Kentucky/index.php

Villamil, M.B., E. D. Nafziger, and G.D. Behnke. 2019. New grain P and K concentration values for Illinois field crops. Crop Forage Turfgrass Manage. 5:180090. doi:10.2134/cftm2018.11.0090

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Corn Nitrogen Rate Recommendations: AGR-1 Updates

Dr. John Grove, UK Soil Specialist and Edwin Ritchey, UK Extension Soil Specialist

Corn fertilizer nitrogen (N) ***rate*** recommendations had not been deeply reexamined in 20 years. Additionally, there have been no substantial change to AGR-1 (Ritchey and McGrath, 2020) corn N ***management*** recommendations since the 2004-2005 version of the document. Information on the use of urease inhibitors was added at that time. Other N management recommendations last changed in the 2002-2003 edition, when text supporting use of management alternatives to surface urea application after May 1 were added. This does not mean that research results regarding corn N rate recommendations have not been considered. These evaluations did not find enough evidence supporting a change. Corn producers and extension personnel have voiced concern that current corn N rate and management recommendations were not sufficiently modern/nuanced, considering more of the N management practices available to corn producers.

In response to a 'data call', 174 grain yield N response data sets/entries, from the 2013 to 2023 production seasons, were submitted by UK Plant and Soil Science faculty. Each entry consisted of two or more N rates and the same number of yield values and was accompanied by meta-data that permitted 'binning' of the data. Bins permit comparisons guided by existing AGR-1 N rate recommendations, but additional interesting comparisons were also made. Bins were related to soil drainage; tillage; previous crop; a cereal rye cover crop; manure use; irrigation use; N timing; N placement of the largest N fraction; N loss inhibitor use with the largest N fraction; and location (grower farm vs. research farm). Several of the bins were insufficiently populated and unable to support meta-analysis.

For 152 of the entries there were sufficient N rates, 3 or more, to calculate a corn yield versus N production function. The quadratic-plateau function was favored, but some entries required linear-plateau, quadratic or linear functions. The production functions were used to determine the parameters that were binned: the maximum yield (YAONR), the corresponding agronomic optimum N rate (AONR), the maximum economic yield (YEONR), and the corresponding economic optimum yield (EONR). To find YEONR and EONR, a N to corn price ratio of 0.1 (ex. $0.50/lb N:$5.00/bu corn) was assumed. The AONR, YAONR, EONR and YEONR values were subjected to the binning meta-analysis.

Cumulative frequency distributions were developed to visualize the parameter bin populations. These distributions are determined by dividing 100% by the number of observations for a given parameter and then plotting the cumulative frequency percentage (y-axis) as a function of the parameter value (lowest to highest) on the x-axis. Figure 1 illustrates the cumulative frequency distributions for EONR (Fig. 1a) or YEONR (Fig. 1b) values, depending upon whether a winter cereal cover crop (usually rye) was present (n = 49) or not (n = 103) prior to corn planting. In general, there was a greater spread in EONR values (0 to 352 lb N/acre) than in YEONR values (87 to 286 bu/acre). The EONR populations were significantly different with median values of 155 and 193 lb N/acre in the absence and presence of the cover crop and reflecting that the respective distributions lie to the left (without cover crop) and the right (with cover crop) of the 'All Data' distribution of EONR values (Fig. 1a). The YEONR distributions were not significantly different, with median values of 201 and 207 bu/acre in the absence and presence of the cover crop, respectively (Fig. 1b).

Figure 2 illustrates the impact of previous grain crop on EONR and YEONR value distributions. Where corn was the previous crop (n = 49 entries), the EONR distribution shifted to the right and the median EONR was higher, 186 lb N/acre, than when either soybean (n = 90 entries) or wheat/double crop soybean (n = 11 entries) was grown previously. With the latter two previous crops, distributions shifted to the left and median EONR was lower, 161 lb N/acre (Fig. 2a). The YEONR distributions shifted in the opposite direction; corn after corn yields were lower, mean of 199 bu/acre, and corn after soybean or wheat/double crop soybean yields were higher, mean of 219 bu/acre (Fig. 2b). In this comparison, YEONR differences due to previous crop were greater at the high yield end of the YEONR distribution, indicating greater positive impact of crop rotation in high yield environments (Fig. 2b).

Figure 1. The EONR (a) and YEONR (b) value distributions as related to presence of a rye cover crop.

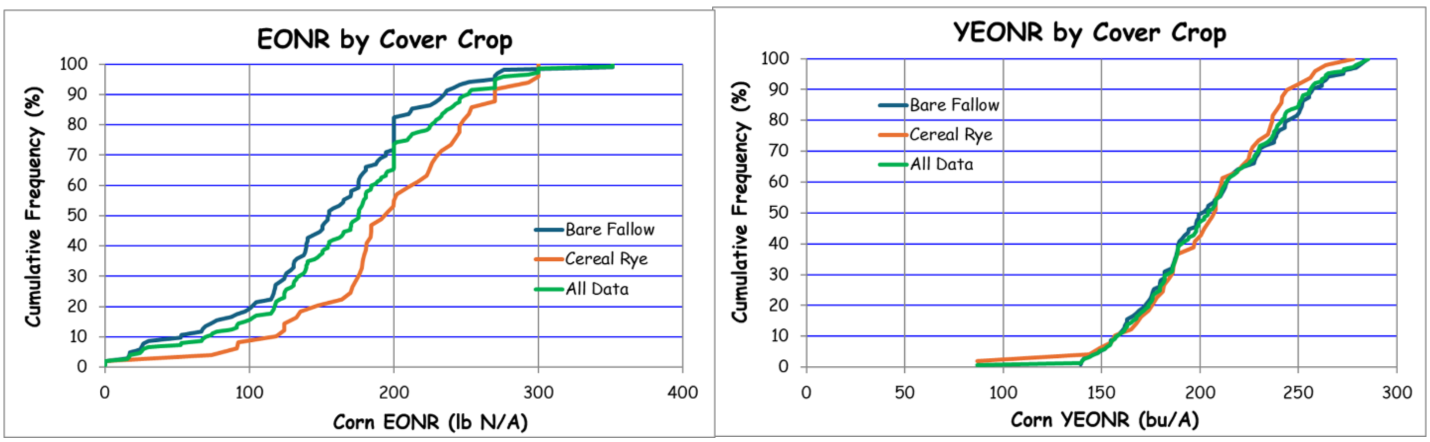


Figure 2. The EONR (a) and YEONR (b) value distributions as related to the previous crop.

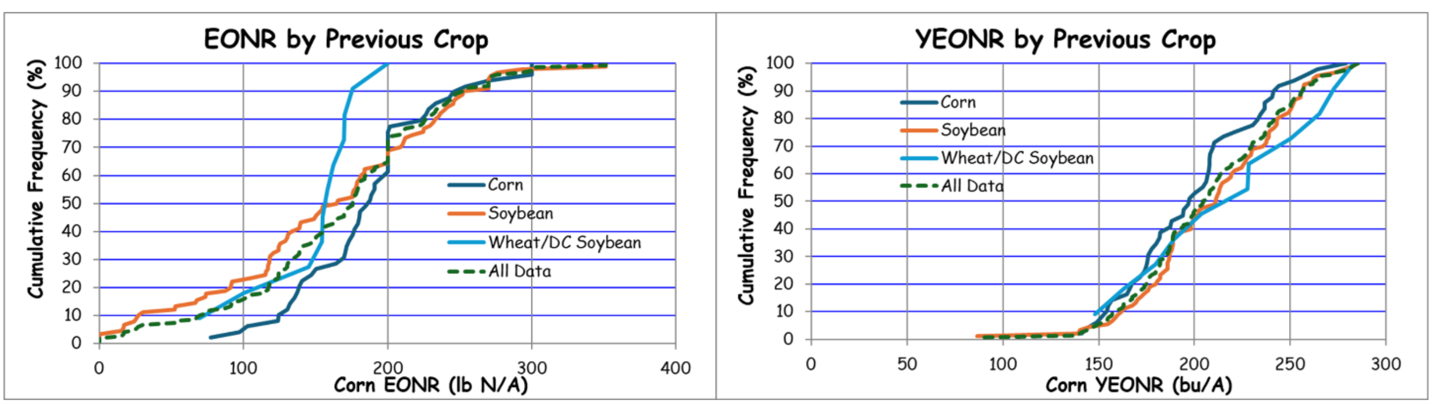
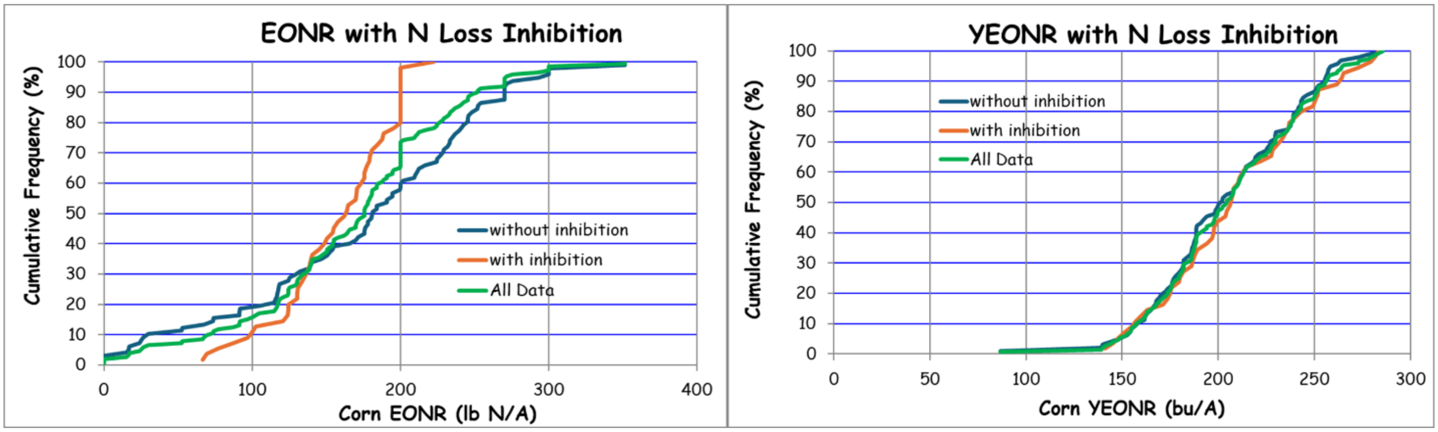


Figure 3 illustrates the impact of N loss inhibitor (usually a urease inhibitor) use on EONR and YEONR value distributions. The YEONR values were similar across the distribution and averaged 201 bu/acre where no inhibitor was used (n = 97 entries), and 207 bu/acre where an inhibitor was present (n = 55 entries). The EONR value distributions were not similar, pulling away from each other when the situation required more

N nutrition (at higher EONR values). In these cases, the use of the inhibitor reduced EONR values even more.

Figure 3. The EONR (a) and YEONR (b) value distributions as related to the use of an N loss inhibitor.



The previous corn N rate recommendations (Figure 4) were binned according to previous crop, tillage and soil drainage class. There were three previous crop categories (corn was lumped with the other grain crops), tillage differences were established according to the degree of residue cover, and soil drainage classes did not include the somewhat poorly drained class. Other N rate influencing factors were in footnotes and text that accompanied the table in Figure 4.

Figure 4. Current AGR-1 (Ritchey and McGrath, 2020) corn N rate recommendations. First column head contains an error (reads as 'Cover Crop' instead of 'Previous Crop') as found in the original document.

Table 12. Recommended application of nitrogen (lb N/A), corn.[1]

Cover Crop	Tillage[3]	Soil Drainage Class[2]		
		Well-Drained	Moderately Well-Drained[4]	Poorly Drained
Corn, sorghum, soybean, small grain, fallow	Intensive	100 - 140	140 - 175	175 - 200
	Conservation	125 - 165	165 - 200	
Grass, grass-legume sod (4 years or less), winter annual legume cover	Intensive	75 - 115	115 - 150	150 - 175
	Conservation	100 - 140	140 - 175	
Grass, grass-legume sod (5 years or more)	Intensive	50 - 90	90 - 125	125 - 150
	Conservation	75 - 115	115 - 150	

1 Nitrogen rate for irrigated corn should be increased to 175 to 200 lb N/A.
2 Soil drainage class examples are given on Page 2.
3 Intensive tillage has less than 30% residue cover, and conservation tillage has more than 30% residue cover on the soil at planting.
4 Poorly drained soils that have been tile drained should be considered moderately well- drained.

The new recommendations are in two tables (Figure 5) separate corn/sorghum from other prior grown grain crops, simplify "Tillage" as no-till versus any tillage prior to planting, and split the four soil drainage classes into two bins. Table 12a assumes no inhibitor or rye cover crop use. Table 12b clarifies the impact of those two practices on the recommended corn fertilizer N rate.

Figure 5. New AGR-1 corn N rate recommendations.

Table 12a. Recommended nitrogen application rate (lb N/A) for dryland corn.[1]

Previous Crop	Tillage[3]	Soil Drainage Class[2]	
		Well and Moderately Well Drained[4]	**Somewhat Poorly and Poorly Drained**
Corn, Sorghum	No-Till	160-190	175-205
	Tilled	150-180	165-195
Soybean, Small Grain, Fallow	No-Till	140-170	155-185
	Tilled	130-160	145-175
Grass, Grass-Legume (≤ 4 years), Winter Annual Legume Cover Crop	No-Till	110-140	125-155
	Tilled	85-115	100-130
Grass, Grass-Legume (≥ 5 years)	No-Till	85-115	100-130
	Tilled	60-90	75-105

[1] Assumes no cereal rye cover crop ahead of corn planting. Assumes no N loss inhibitor used.
[2] Soil drainage class examples are given on Page 2.
[3] No Till = no primary or secondary tillage, fall or spring, prior to planting the crop. Tilled = any primary or secondary tillage, fall or spring, prior to planting the crop.
[4] Somewhat poorly or poorly drained soils that have been tile drained should be considered moderately well drained soils.

Table 12b. ***Cereal rye cover crop and/or urease inhibitor use:***[1] Recommended total nitrogen application rate (lb N/acre) for no-till dryland corn grown on well and moderately well drained soils and where two-thirds or more of the total N rate top/side-dressed with surface applied urea-containing fertilizer in the absence/presence of a cereal rye cover crop without/with use of a urease inhibitor.

Previous Crop	Cereal Rye Cover Crop[3]	Recommended Total N Rate (lb N/acre)	
		No Inhibitor	**With Inhibitor[2]**
Corn, Sorghum	No	160-190	150-180
	Yes	185-215	165-195
Soybean, Small Grain, Fallow	No	140-170	135-165
	Yes	165-195	150-180

Compared to the prior recommendations, some bin categories declined (e.g., soil drainage classes dropped from 3 to 2), and certain bin categories increased (e.g., previous crop categories rose from 3 to 4). New bin categories/scenarios were found to impact corn yield N response and resulted in new recommendations (e.g. without/with a cereal rye cover crop; without/with a N loss inhibitor). Current fertilizer N rate recommendations depend on the given scenario and are given as an N rate range. The new recommendations generally compress the recommended range relative to the old recommendations, usually by raising the low end of the range without greatly increasing the high end of that same range.

There are some additional needs, going forward. In the newer data, different tillage practices resulted in less difference in EONR values, but there were fewer experiments where the soil was tilled. Irrigation resulted in higher yields, but in the few irrigated studies that were done there was little need for additional N relative to the mean EONR for rainfed corn grown under otherwise similar conditions. The existing fertilizer N rate recommendation will be continued, but again, more irrigated study data are needed.

There was only a small reduction in the total EONR rate (12 lb N/acre) with delaying two-thirds or more of that total fertilizer N rate at least four weeks after planting. However, most of the new data were generated on moderately well and well drained soils. The current delayed fertilizer N rate recommendation was primarily intended for somewhat poorly and poorly drained soils and will remain as is. There were no trials where corn was grown after a forage crop. There is often a wide range in corn planting dates within a given planting season, but there was no study that looked at the corn yield N rate response as a function of planting date, or at the corn response to delayed N timing as a function planting date.

Though there have been some increases in the recommended corn fertilizer N rates (most notably in the presence of a winter cereal rye cover crop and where corn follows corn) the data indicate that continuing improvements in crop and N management practices have increased N use efficiency quite significantly. A lot of the reported studies exhibited apparent fertilizer N use efficiencies between 0.7 and 0.8 lb N/bu – 155 to 175 lb N/acre produced yields around 220 bu/acre. The mean YEONR yield values found in these studies and used to develop these fertilizer N rate recommendations are well above current state-average yields. The ongoing yield trend with time indicates that corn N research needs to be revisited every 5 to 10 years with the objective of evaluating these corn N rate and management recommendations.

Ritchey, E., and J. McGrath. 2020. 2020-2021 Lime and Nutrient Recommendations, AGR-1. Univ. Kentucky Coop. Extn. Svc., Lexington, KY.

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