Pattern Ag

2024
Predictive Ag Report

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Connecting Genomics & Agronomy
LETTER FROM THE CEO

Pattern Ag's mission is to help farmers and their advisors make the most productive, profitable management decisions. Is a corn rootworm trait stack worth the investment? Is a hidden fungal pathogen silently robbing soybean yield? In the past, we had to make an educated guess. But today, using genomic technology, we can digitize the biology of the farm so we can know next season's risks and match the right input to the right field. We call this **'Predictive Ag,'** and our customers are using it to supercharge agronomic planning with data, placing products with confidence and precision. Today, it helps farmers maximize their yield and minimize their input costs. In the future, it will allow agronomists to predict the yield impact of each individual product, customized to each individual field.

To power Predictive Ag, our scientific focus has been **connecting biology to agronomic outcomes.** Our team works tirelessly to help agronomists and farmers understand how the things living in their field drive yield. Genomic data opens up new opportunities to boost crop yields through precision field analysis on an unprecedented scale. This year, along with our 2024 Predictive Almanac, we are introducing a new section: 2024 Yield Opportunities. This section combines metagenomic, biochemical, and agronomic data to quantify which pests and diseases robbed farmers of the most yield last fall. Think of it as a playbook for trusted advisors to help farmers prioritize and manage yield robbers that went unmanaged in 2023. And it is eye-opening: Some diseases going unmanaged today are robbing well over 30 bu/ac!

In addition to our scientific progress, we rolled out two new commercial products this fall: **foliar pathogens** and **soil productivity.** With foliar pathogen analytics, we now cover above-ground risks, informing key scouting and foliar application decisions. Soil productivity is our analytic framework to help farmers take action on soil health. Our definition of productivity is simple: Soil that maximizes agronomic output per unit of input. Researchers have shown that healthy soils natively resist pathogens and provide much of the fertility needed for plant growth. Because of this, our vision for measuring soil health is pragmatic: Healthy soils are productive soils. In short, sustainability and productivity are aligned: We just need to give farmers a roadmap to determine how to build up their soils. Our soil productivity metric provides that roadmap; we are offering it as a beta product this year for free.

Last year, Pattern Ag announced that we had built the **largest metagenomics database in the world**. That database only continues to grow: **64** TeraBases as of this printing. We thank our customers and our partners for helping us make this happen. In this report, we synthesize the findings from our genomics database and share anonymized, aggregated views of our market intelligence with the broader agricultural community as a way of giving back. If you are interested in working with us, please reach out!

Rob Hranac
CEO, Pattern Ag

Pattern Ag Unveils the World's Largest Soils Database

MAPPING THE MIDWEST CORN/SOYBEAN MICROBIOME

At Pattern Ag, we build our insights by sequencing all of the DNA present in a soil sample. The scale of this metagenomic dataset is unparalleled in the world of precision agriculture and is the largest amount of data for a single ecosystem. As of the time of writing this, our Midwestern database is more than twice the size of the three largest human microbiome sequencing projects combined and is approaching twice the size of the Tara Global Oceans database. This means that we have more insight into the microbiology of midwest row crops than the health field has about the human body.
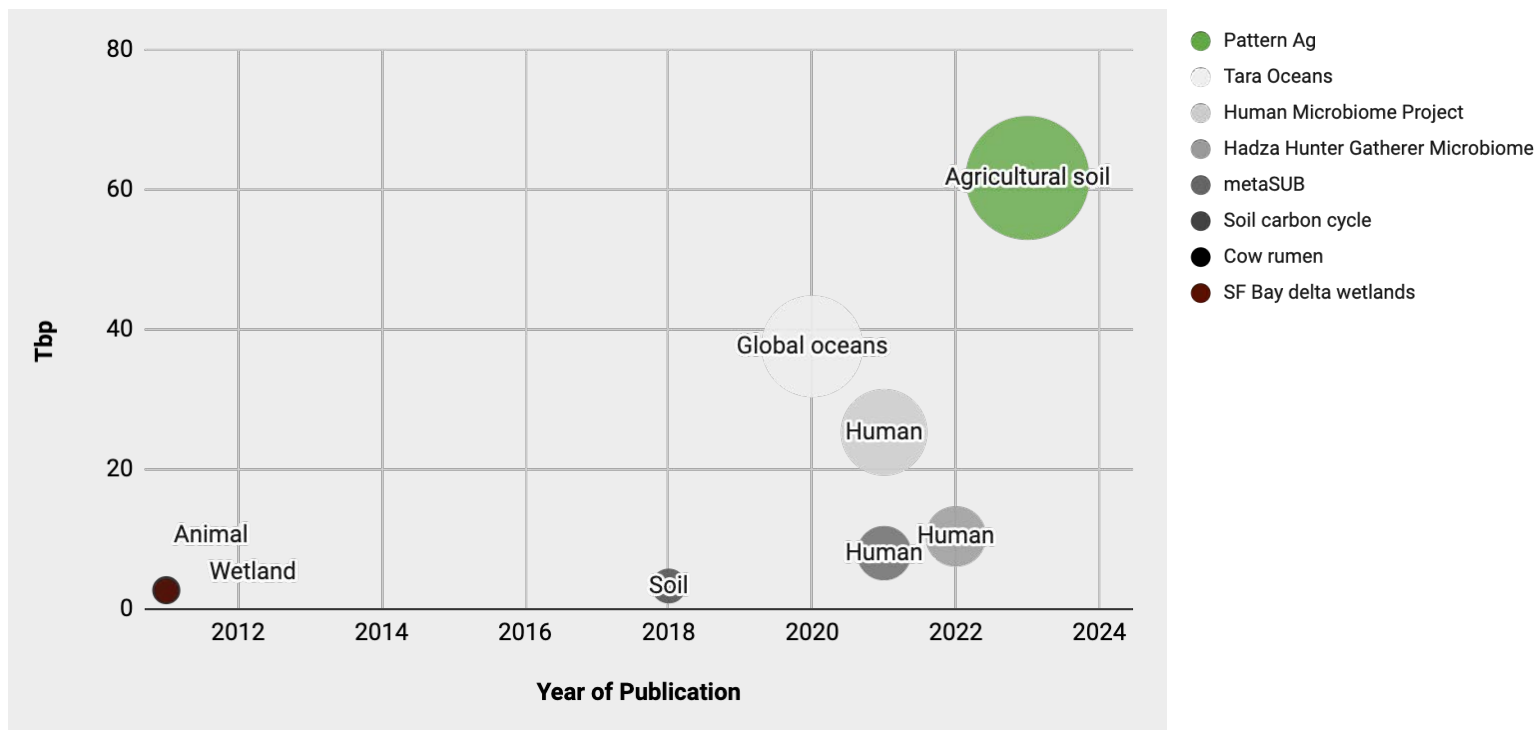
Pattern Ag's dataset is a game-changer, delivering the most accurate and actionable results.

Navigating Next Season:

PATHOGEN PRESSURE MAPS HELP PREDICT NEXT SEASON'S BIGGEST RISKS

Pattern Ag's Predictive Maps

Since Pattern Ag's early days, our north star has been making it easier for growers to use precision management in their fields. Our insights have focused on helping our growers understand the risks to their upcoming season, making crop protection more targeted and effective, and placing the right biologicals to make the most significant difference.

In this report, we are unveiling the early days of the next evolution of our insights: **predicting yield**. In the coming pages, we will highlight the regions where we saw the biggest yield differences with high-risk insights. We like to think of these as opportunities for more aggressive management.

These maps offer a glimpse into the future, allowing farmers, agronomists, and on-farm decision-makers to anticipate the potential threats to corn and soybeans in the upcoming year.

Our 2024 predictive maps are essential tools that empower you, the agricultural community, to make informed, data-driven decisions, reduce risks, enhance productivity, and contribute to sustainable and profitable farming outcomes across the Midwest.

HOW TO READ THE ALMANAC
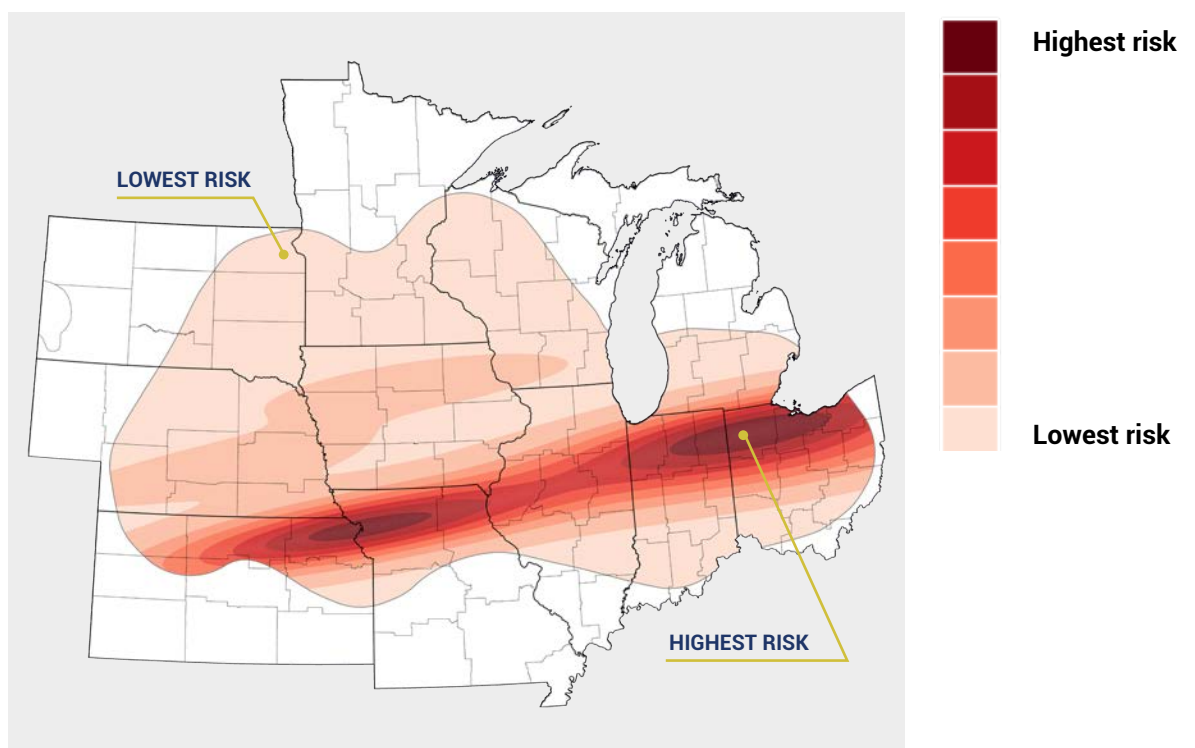
Corn Rootworm
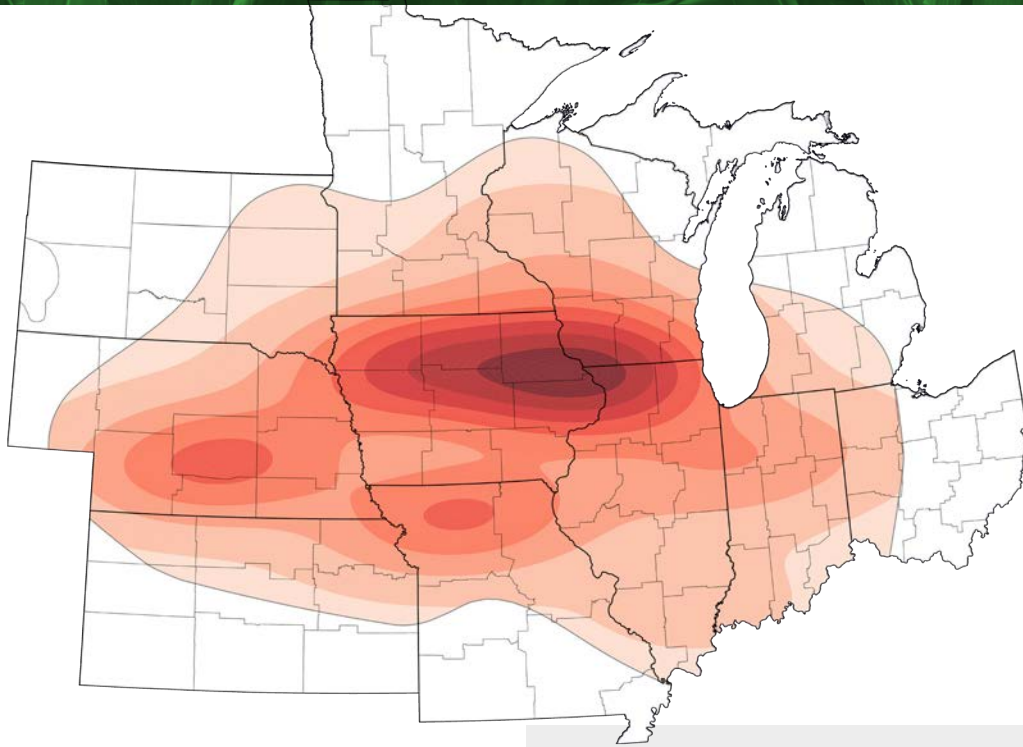
INFECTION SPOT

LARVAE: Roots

ADULTS: Silks

INFECTION TIMING

Rootworm larvae will feed on corn roots while adults will feed on the silks. Rootworm eggs will usually hatch when soil temperature is >52 degrees and eggs are moist. Up to 50% of rootworm eggs will hatch when 684-767 GDD units have accumulated, with all eggs hatching within 29-32 days.

AGRONOMIST NOTES

- Rootworm is particularly bad in the western part of the Midwest, including Iowa, Nebraska, South Dakota, and Minnesota. It is less of a problem in the eastern states of the Midwest.

- We observe higher risk for fields planting out of corn, as expected, especially in Iowa.

TREATMENT

Treatment is the same for both Northern and Western corn rootworms; Bt traits provide the most effective form of control, and for added protection, in-furrow insecticides can be applied when planting. Rootworm populations continue to develop resistance to Bt traits, and trait failures are becoming more common. Consider a pyramid of traits and multiple protection modes in high-risk fields.

In-furrow insecticide treatments applied at the time of planting include:
Groups 1 (ex. terbufos), 2 (ex. fipronil), and 3 (ex. lambda-cyhalothrin) insecticides with an in-furrow CRW label. Treatments containing more than one mode of action is highly recommended to avoid resistance development.

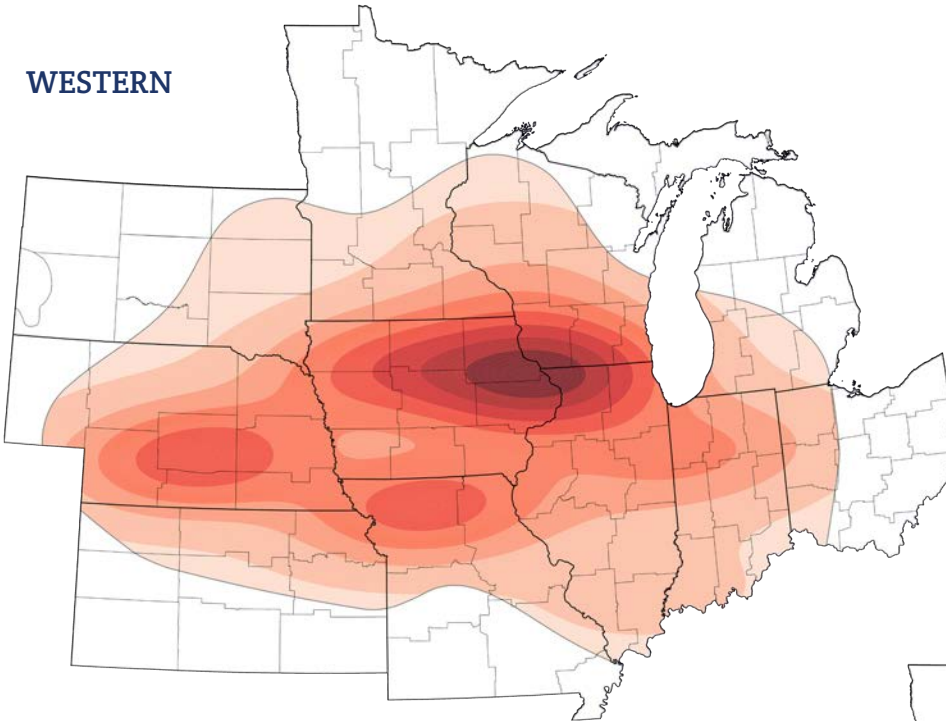**Post-plant insecticide "rescue" treatments include:**
Groups 1 (ex. chlorpyrifos) and 3 (ex. tefluthrin) insecticides with a post-planting application label for CRW.

NOTE: Many insecticide options for treatment of CRW are classified as "Restricted Use Pesticides"
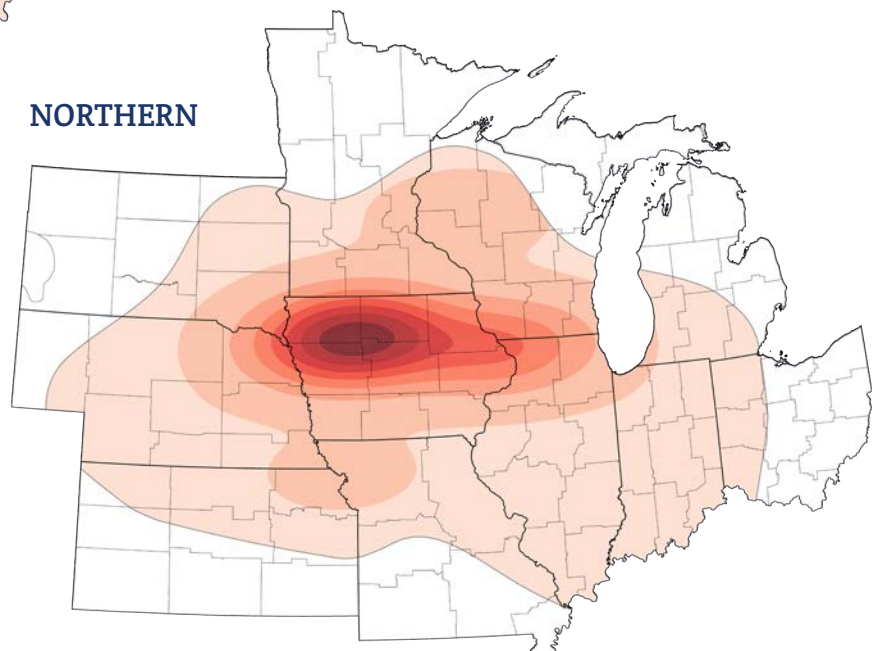
Western and Northern Rootworm

WESTERN

Winston Beck, Iowa State University, Bugwood.org

NORTHERN
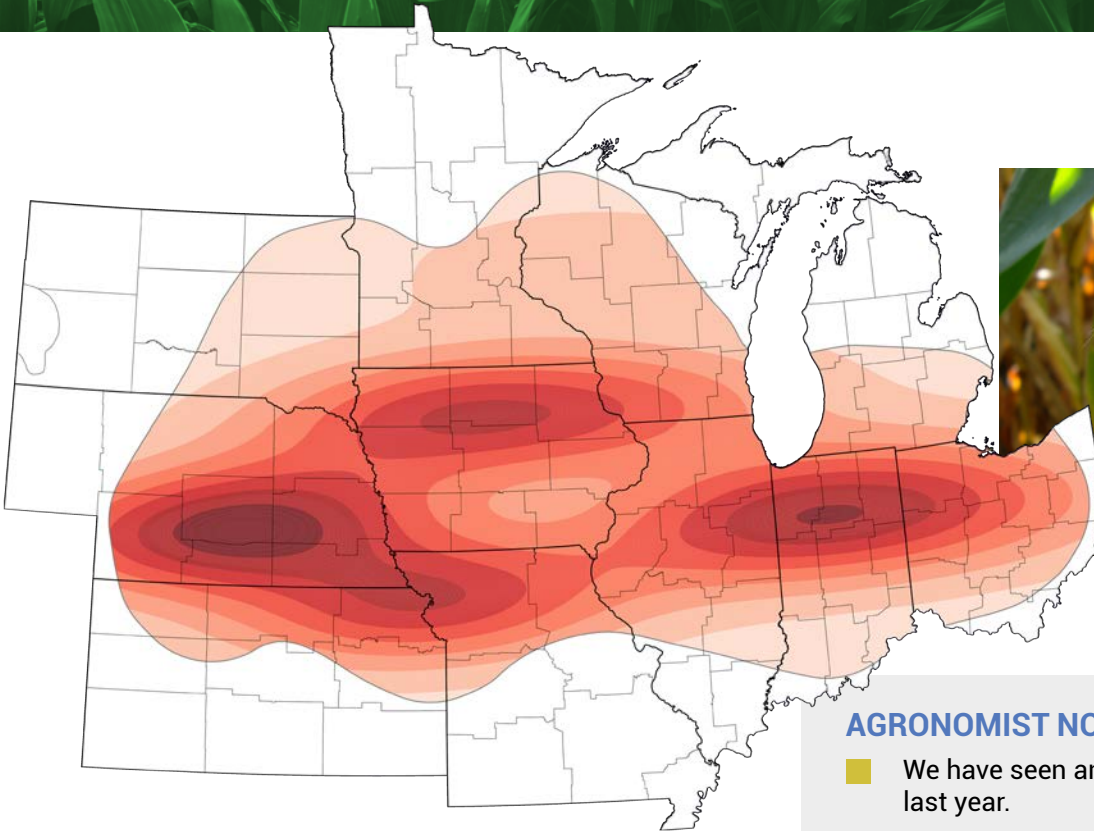

Daren Mueller, ISU, Bugwood.org

AGRONOMIST NOTES

- WCRW females are known to lay eggs in fields of soybeans and other non-corn crops. This means crop rotation may not be an effective form of control. The only way to be sure your field is clean is to analyze for egg pressure.

- WCRW tends to produce more eggs per female during a growing season, resulting in increasing WCRW pressure over time when compared to NCRW populations.
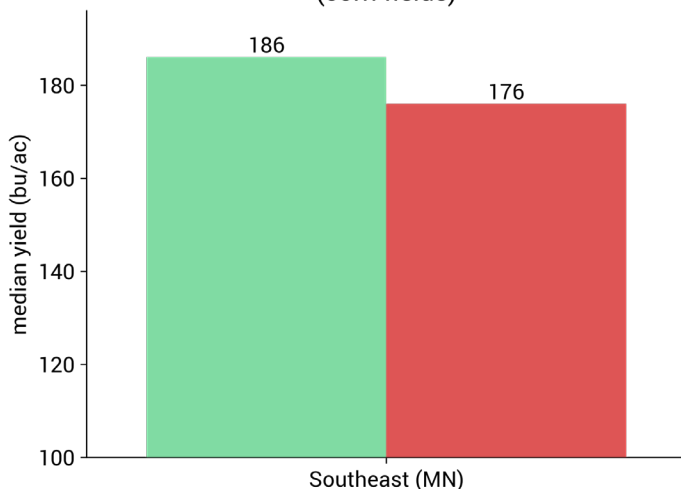
Gibberella

Alison Robertson, Bugwood.org

Gibberella Stalk Rot
(corn fields)

186 — Southeast (MN) green bar

176 — Southeast (MN) red bar

y-axis: median yield (bu/ac) — 100, 120, 140, 160, 180

x-axis: Southeast (MN)

AGRONOMIST NOTES

- We have seen an increase in risk compared to last year.

- Also causes fusarium head blight in wheat.

- In Southeastern Minnesota, we observed a 10 bu/ac decrease in corn yield in high-pressure Gibberella fields.

📍 INFECTION SPOT

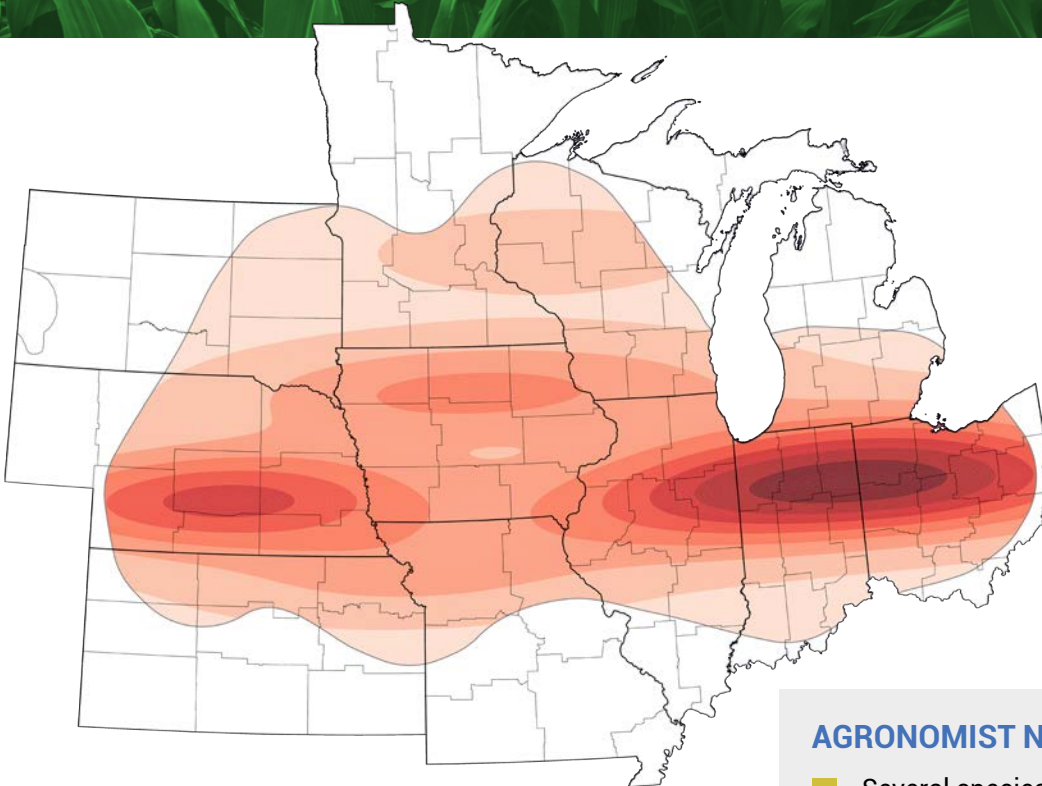Roots, stalk, and ear/silks

INFECTION TIMING

Infection occurs in the roots during emergence or planting.

TREATMENT

For management, use seed treatments containing one or more of the following AIs — azoxystrobin, carboxin, fludioxonil, fluxapyroxad, ipconazole, penflufen, prothioconazole, sedaxane, trifloxystrobin. Also, consider chemistries that provide systemic protection throughout the season.

Fusarium

Alison Robertson, Bugwood.org

Fusarium (corn fields)

median yield (bu/ac)

- Northeast (IL): 238, 202
- North Central (IA): 234, 152

Fusarium (soybeans fields)

median yield (bu/ac)

- Southeast (SD): 71, 47

TREATMENT

Seed treatments containing one or more of the following AIs — azoxystrobin, carboxin, fludioxonil, fluxapyroxad, ipconazole, penflufen, prothioconazole, sedaxane, trifloxystrobin.
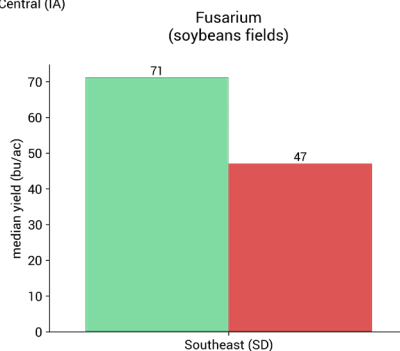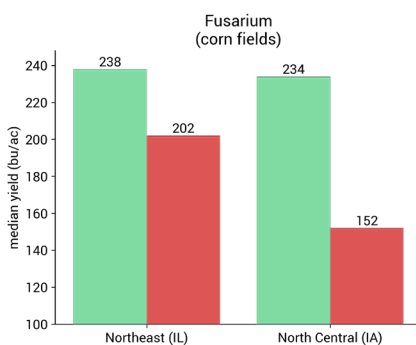
AGRONOMIST NOTES

- Several species cause Fusarium Root Rot, some associated with drier conditions and others with wetter conditions. Although induced by different species, this results in a relatively high risk across the Midwest.

- In corn, high Fusarium pressure was linked to yield loss of up to ~33 bu/ac across the Midwest. In North Central Iowa, it was associated with a difference of 80 bu/ac (see North Central Iowa Vignette for more information). These regions could benefit from more aggressive management of Fusarium pressure, which could include additional crop protection on seed and in-furrow, along with management changes like tiling and adjusting the planting date.
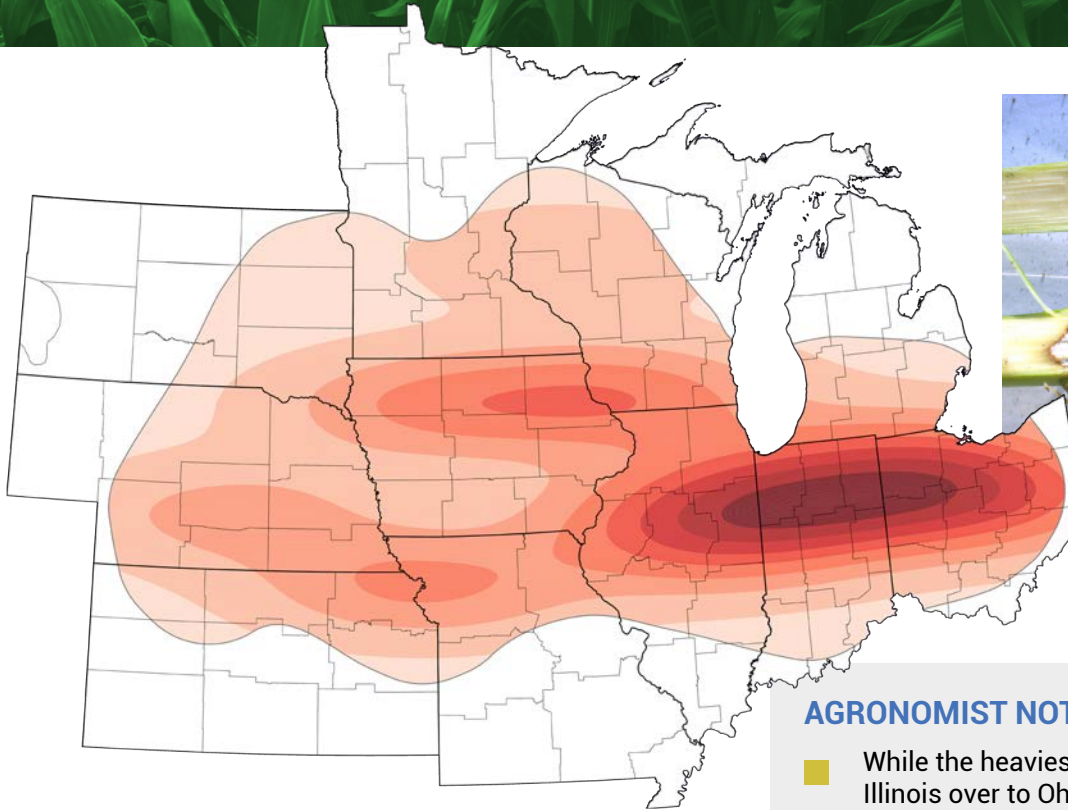
📍 INFECTION SPOT

Roots

INFECTION TIMING

Fusarium will infect corn and soybean roots during emergence and/or planting.

Pythium

Alison Robertson, Bugwood.org

Pythium (soybeans fields)

	Northeast (IL)	Southwest (MN)
median yield (bu/ac)	68 / 65	65 / 58

Pythium (corn fields)

	Southwest (MN)
median yield (bu/ac)	214 / 178

AGRONOMIST NOTES

- While the heaviest pressure is through central Illinois over to Ohio, we are seeing a significant increase year over year in Southwest Minnesota for both corn and soybean fields.

- Risk appears to be shifting southwards due to lower May-July soil temperatures, higher overcast, and moist soil conditions.

- Elevated Pythium pressure has been linked to significant yield losses, with an over 36 bu/ac difference observed in Southwest Minnesota.
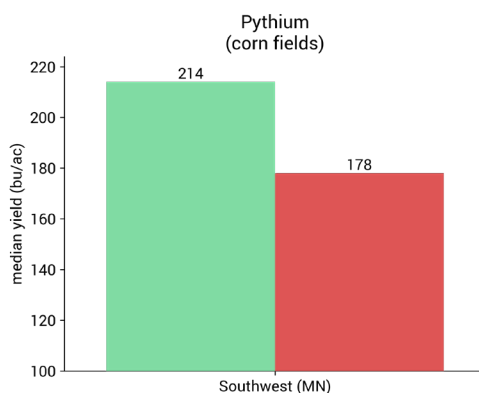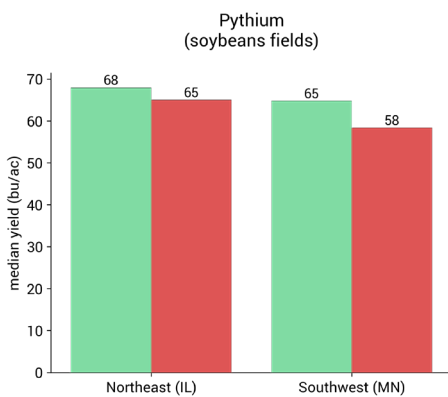
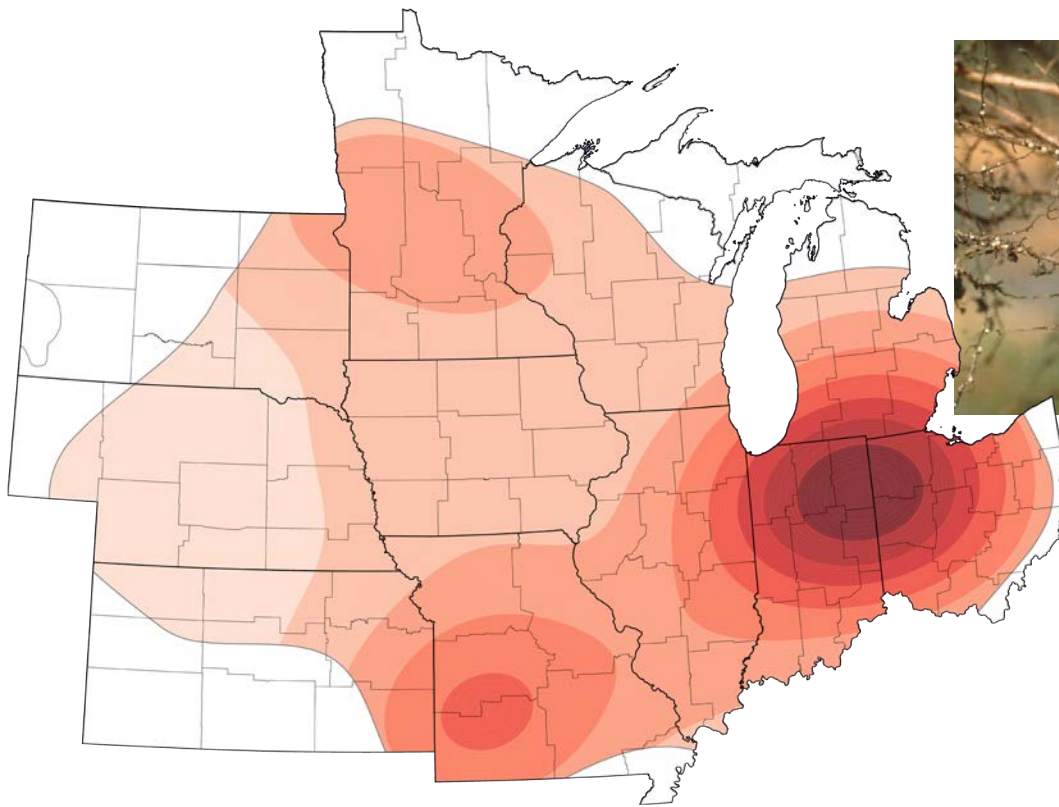## 📍 INFECTION SPOT

Roots

INFECTION TIMING

Pythium infects the roots of corn and soybean crops typically during emergence or planting.

TREATMENT

To manage, use seed treatments containing one or more of the following AIs — ethaboxam, mefenoxam, metalaxyl, oxathiapiprolin

Soybean Cyst Nematode

Gregory Tylka, Iowa State University, Bugwood.org

TREATMENT

The first line of defence against SCN comes from selecting a variety with good resistance — typically PI-88788 or Peking. For additional protection, SCN can be managed with seed treatments containing at least one of the following AIs — abamectin, harpin protein, **Bacillus firmus, Pasteuria nishizawae**, fluopyram, **Bacillus amyloliquefaciens**, Pydiflumentofan, **Burkholderia amyloliquefaciens cisjasmone, Burkolderia ronojenses, Bacillus licheniformis** strain FMCH001, Thiodicarb.

📍 INFECTION SPOT

Roots

AGRONOMIST NOTES

- The overall risk across the Midwest for 2024 appears similar to last year.

- Soybean Cyst Nematode infection in the roots opens the plant up to other infections. It is therefore very important it is co-managed with other soil-borne risks.

- Over the past year, we made significant improvements to this analytic. We are now able to estimate the absolute number of eggs in the soil for a more refined view of your soil risk conditions.

INFECTION TIMING

Emergence, planting

Sudden Death Syndrome
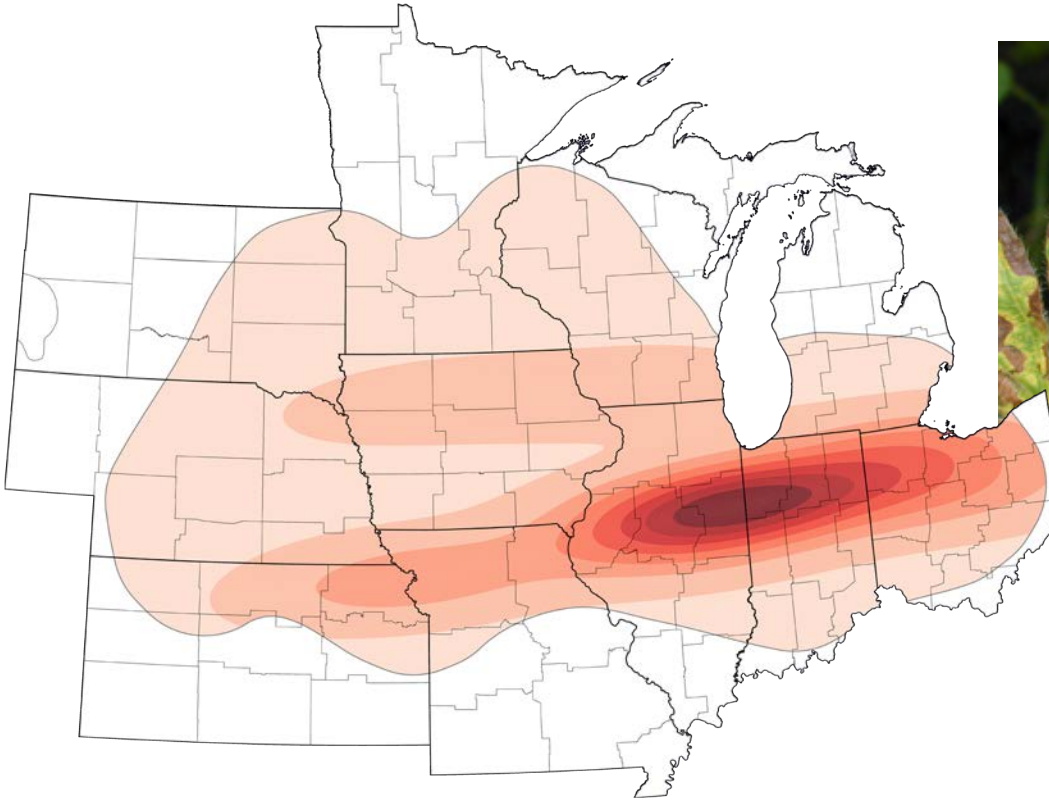
Daren Mueller, ISU, Bugwood.org

TREATMENT

Sudden Death Syndrome is best managed with resistant varieties and through the use of seed treatments containing one or more of the following AIs — pydiflumetofen or fluopyram.

📍 INFECTION SPOT

Roots

INFECTION TIMING

Emergence, planting

AGRONOMIST NOTES

- Pattern Ag's test is linked to the risk of above-ground expression the following year. In previous years we observed a strong link to yield loss, but the dry conditions persisting across the Midwest this year prevented much of the expression we usually observe.

- This pathogen is able to persist in corn fields, so rotating out of soybean alone can be insufficient for reducing the risk of this pathogen for the next soybean rotation in high-risk regions.

- Weather and soil moisture are highly associated with infection of SDS. For 2024 look for higher soil moisture and temperatures in late winter through planting to understand if the weather will increase your risk of expression.

Phytophthora
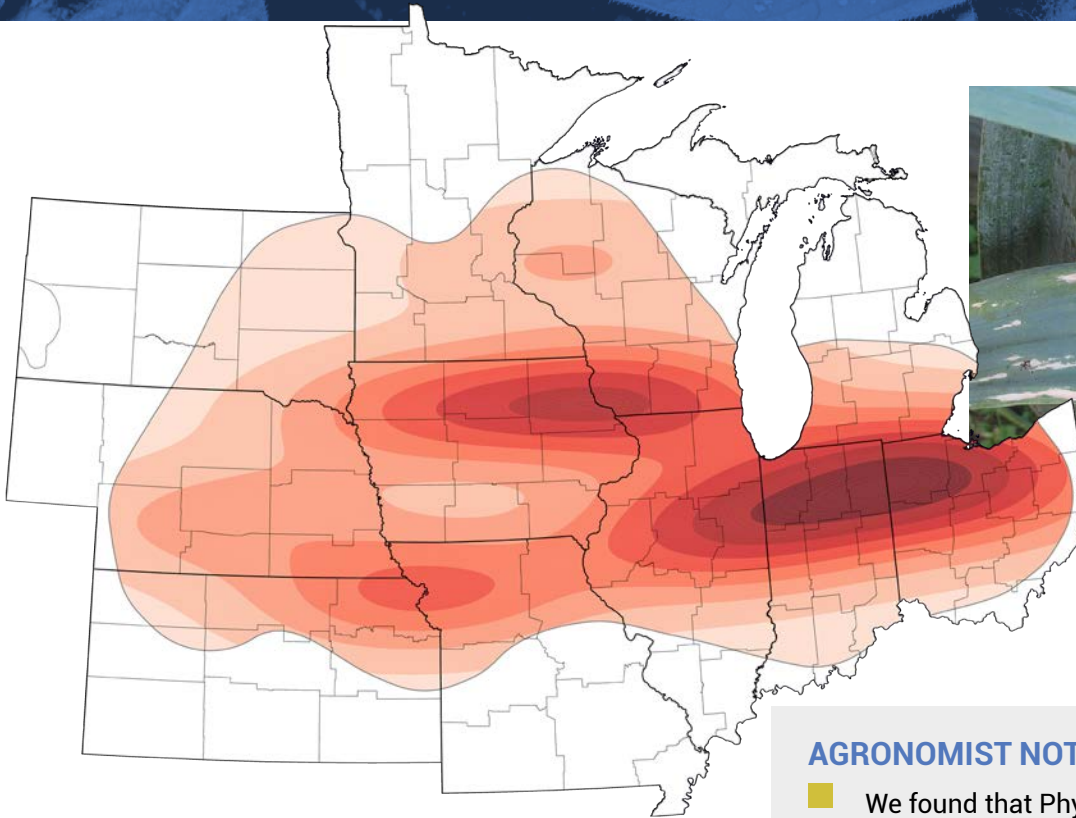
WIKIPEDIA
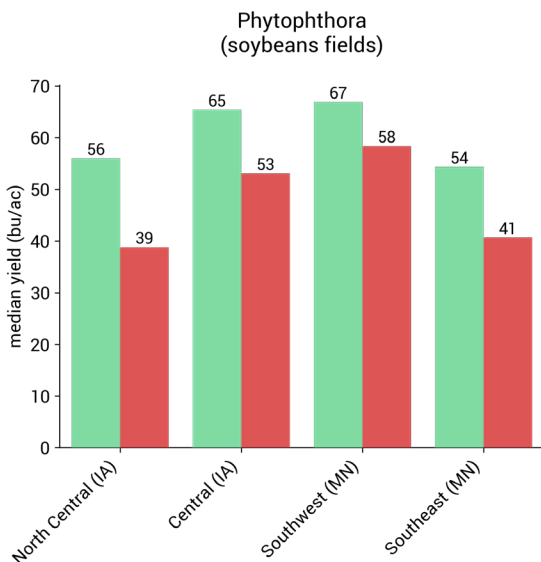
AGRONOMIST NOTES

- We found that Phytophthora is broadly associated with high moisture during planting periods. This is especially true in regions with high soil moisture during the month of April.

- Areas of high Phytophthora pressure that were linked to 8.5 to over 17 bu/acre soybean yield loss in 2023 included North Central Iowa, Southwest and Southeast Minnesota.

TREATMENT

To manage, select resistant varieties and use seed treatments containing at least one of the following AIs — ethaboxam, mefenoxam, metalaxyl.

📍 INFECTION SPOT

Roots

INFECTION TIMING

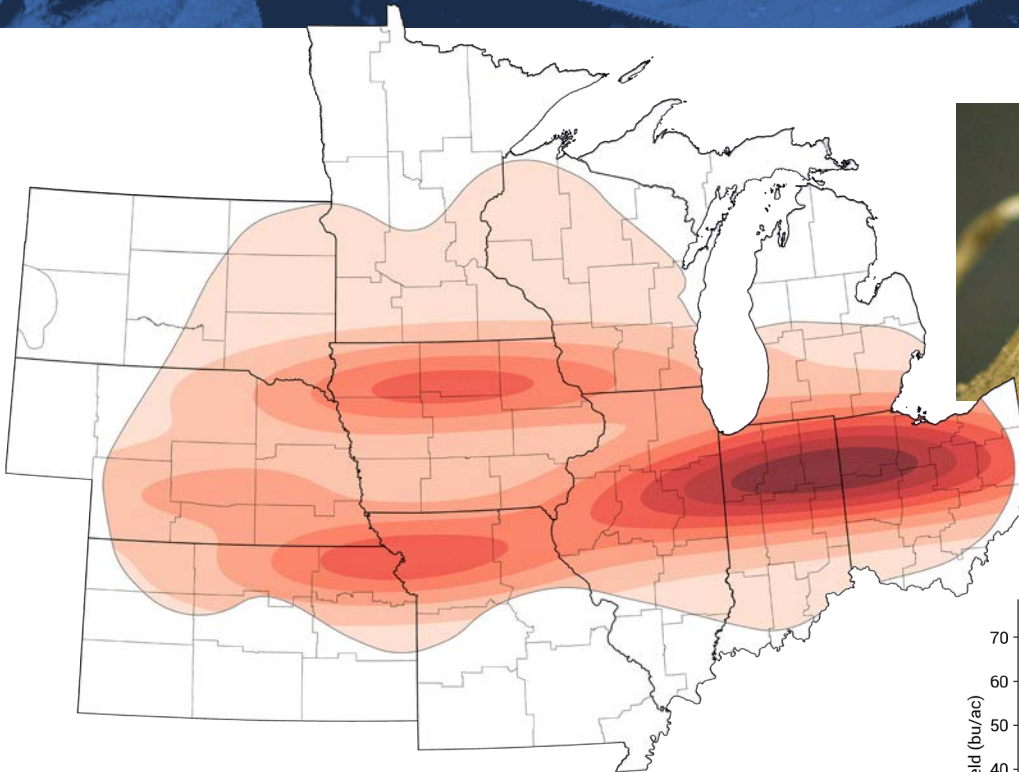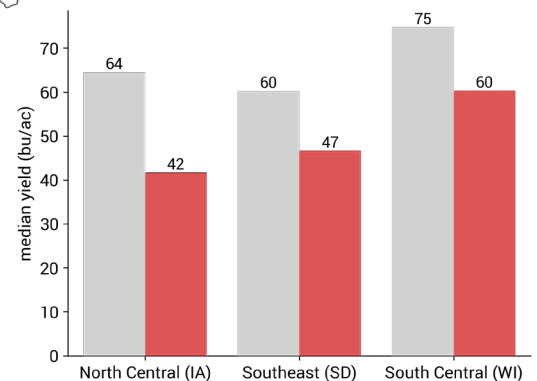Phytophthora will infect the roots of soybeans crops during emergence or planting.

Phytophthora
(soybeans fields)

median yield (bu/ac)

- North Central (IA): 56, 39
- Central (IA): 65, 53
- Southwest (MN): 67, 58
- Southeast (MN): 54, 41

Charcoal Rot

Charcoal Rot
(soybeans fields)

AGRONOMIST NOTES

- This pathogen favors hot and dry weather conditions. We identified an increased risk in regions that had hotter soil temperatures in May-July.

- This pathogen creates microsclerotia that can persist in the soil for multiple years. High pressure may require consistent management across several rotations.

- Charcoal rot has a large host range. It can infect corn, grain, and sorghum.

- We saw an increase risk this year in Southern Illinois, Missouri, and Kansas.

- We believe there are opportunities for more aggressive rotation management in North Central Iowa, South Central Wisconsin, and Southeast South Dekota, all of which had an average reduced soybean yield on high-risk fields.

📍 INFECTION SPOT

Stem, roots

INFECTION TIMING

Infection can happen anytime, but infection early in the season has the most impact on yield when hot and dry during the early flowering stage.

TREATMENT

Chemical fungicides do not work well on Charcoal Rot. The most effective management methods are variety selection, rotation into small grains, and no-till farming which can reduce heat and moisture stress. Risk can also be mitigated by planting a longer season variety earlier in the spring, which avoids hot conditions during grain fill.

Soybean Brown Stem Rot

Soybean Brown Stem Rot (soybeans fields)

TREATMENT

Chemical fungicides have no impact on Brown Stem Rot. To protect your field, plant resistant varieties, rotate crops, and manage residue. Select resistance varieties.

AGRONOMIST NOTES

- This pathogen is often misdiagnosed as SDS but requires a very different management strategy, and care needs to be taken when selecting resistant seed varieties.

- We're observing higher risk going into 2024 in regions that had high accumulated rainfall between February and April in 2023.

- Risk is slightly lower in Nebraska, North Dakota, and Kansas.

- In 2023 we observed the average yield was 10-20 bu/acre lower in high risk fields in the southern portions of Minnesota, indicating there is an opportunity in these fields for a yield gain with more aggressive management of this pathogen.

📍 INFECTION SPOT

Roots

INFECTION TIMING

Emergence, planting

Soybean Stem Canker

Daren Mueller, Iowa State University, Bugwood.org

Soybean Stem Canker (soybeans fields)

Bar chart — median yield (bu/ac):
- North Central (IA): 66 (green), 46 (red)
- Southwest (MN): 69 (green), 59 (red)

TREATMENT

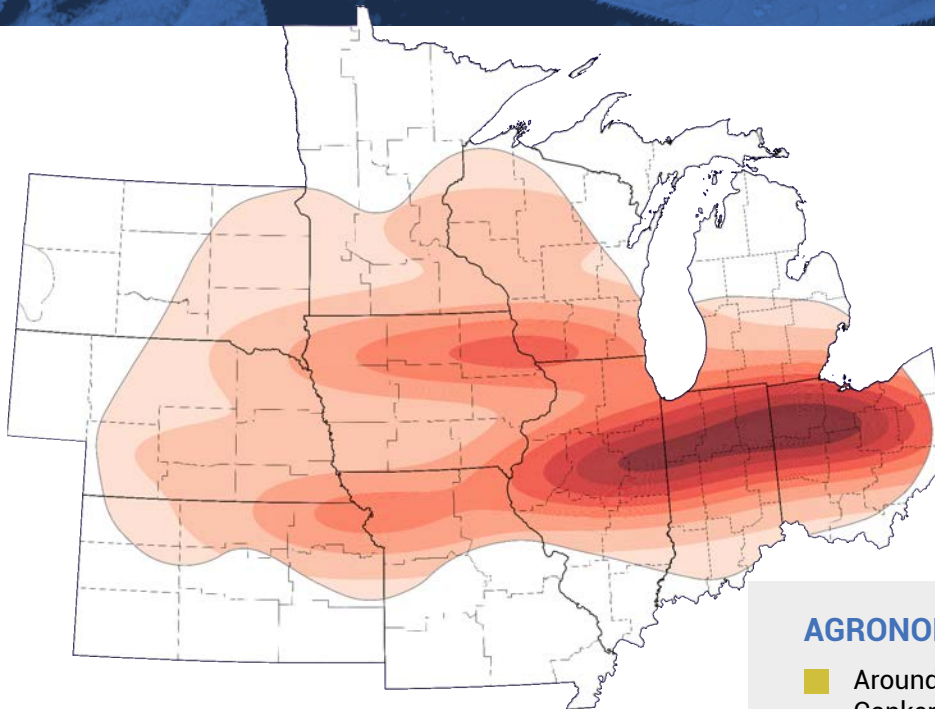The best methods of control will come from variety selection and seed treatments containing one or more of the following AIs — fludioxonil, fluxapyroxad, ipconazole, penflufen, prothioconazole, pyraclostrobin, sedaxane, thiabendazole. In addition, foliar fungicides may help with AIs, including azoxystrobin, fluoxastrobin, pyraclostrobin, trifloxystrobin.

Select resistant varieties.

AGRONOMIST NOTES

- Around 70% of fields are at risk for Soybean Stem Canker, up 12% from last year.

- This pathogen is often confused with Phytophthora root rot, but its lesions do not extend into the soil and have a green cast, whereas Phytophthora will usually extend below the soil and maintain a much whiter cast on the lesions.

- The 2024 regions at higher risk are associated with higher May to June rainfall and higher August temperatures in 2023.

- In North Central Iowa, we saw yield hits of around 20 bu/ac in fields at high risk for Soybean Stem Canker. There may be yield opportunities in increased management in this region.

📍 INFECTION SPOT

Stem, roots

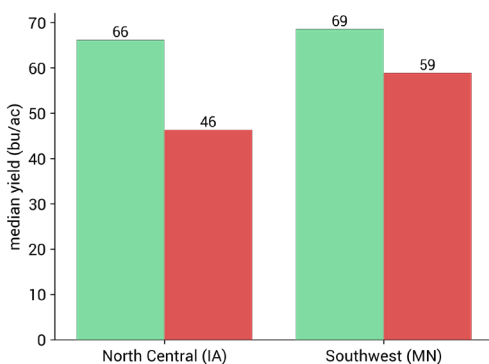### INFECTION TIMING

Emergence, planting
Early vegetative stages prior to R1.

NOTE: Although fungicides can help lessen yield impact, they will not eliminate it; fields with high rates of infection will still see some yield loss. Prevention through variety selection is the best option for management.

Forecasting Foliar Disease

A PROACTIVE APPROACH TO SHIELDING YOUR CROPS FROM PATHOGENS

Tar Spot

Tar Spot (corn fields)

median yield (bu/ac)

- North Central (IA): 213, 181
- Southeast (SD): 168, 119

TREATMENT

Application of multiple modes of action fungicide from VT-R2 is most effective. Single mode of action fungicides are not effective in management. In cases of severe Tar Spot pressure, multiple applications of multiple MOA fungicides may be warranted. It is important to manage infected corn residue after harvest to prevent carry-over into the next year, as well as rotation into soybeans to reduce inoculation load.

AGRONOMIST NOTES

- Tar Spot is favored by humid conditions with extended leaf wetness, and can be a particular problem on irrigated acres. The causal pathogen of Tar Spot is known to also infect foxtail grasses and johnsongrass, which can serve as a host.

- For 2023 we observed lower yield in fields at high risk in Southeast South Dakota, North-Central Iowa, and Central Indiana. The average yield opportunity that could be gained ranges 48.9 bu/ac in South Dakota to 26.1 bu/ac in Indiana.

INFECTION SPOT

Leaves

INFECTION TIMING

At or before VT through R2.

Gray Leaf Spot

Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Gray Leaf Spot (corn fields)

median yield (bu/ac)

241   234

Southeast (IA)

TREATMENT

Planting resistant hybrids is your first line of defense against GLS.

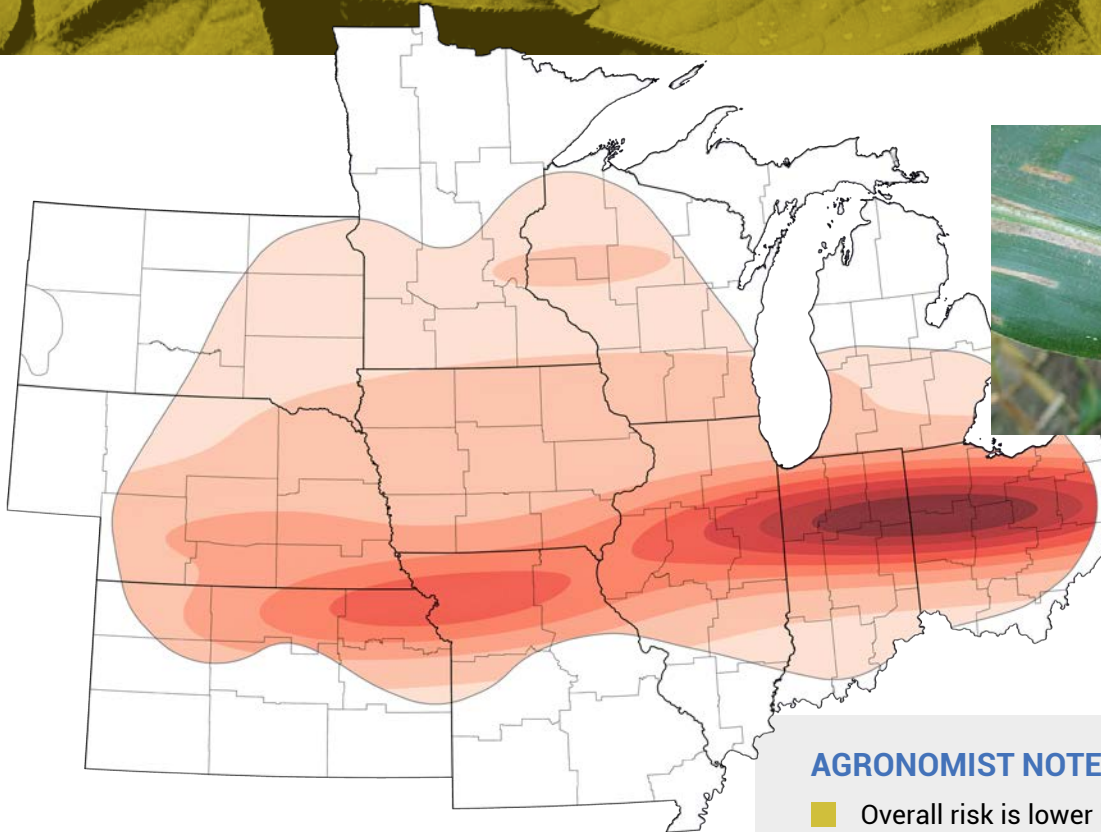Foliar fungicides containing strobin active ingredients such as azoxystrobin, pyraclostrobin, and picoxystrobin are generally effective in GLS management. Applications at V12 reduced GLS severity, more than applications during reproductive growth stages.

AGRONOMIST NOTES

- Overall risk is lower heading into the 2024 season.

- Like the other foliar pathogens, expression is linked to higher humidity.

- High levels of this pathogen were observed in the worst performing fields in Southeast Iowa in 2023, averaging 7 bu/ac lower than the fields with low risk.

- Yield determination is during the vegetative stage. However, the yield impact is occurring at the R5 stage when the plant is devoting more to the ear formation. Where infection is covering > 10% of the leaf area the plant has limited resources, end up with poor grain fill.

⦿ INFECTION SPOT

Leaves

INFECTION TIMING

Critical infection period is during the reproductive stages, with R5 leaf damage being determinative of grain loss.

Northern Corn Leaf Blight

Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Northern Corn Leaf Blight (corn fields)

median yield (bu/ac)

North Central (IA): 213, 179
Southeast (MN): 186, 171

INFECTION SPOT

Leaves

INFECTION TIMING

Before VT for lesions at or above ear leaf.

TREATMENT

Planting resistant hybrids is your first line of defense against NCLB.

QoI foliar fungicides containing strobin AIs such as azoxystrobin, pyraclostrobin, and picoxystrobin.

Triazole foliar fungicides including AIs such as propiconazole, prothioconazole, tebuconazole.

Multiple mode of action fungicides (i.e., those that contain both strobin and triazole actives) are most recommended to enhance control and reduce instances of resistance development.
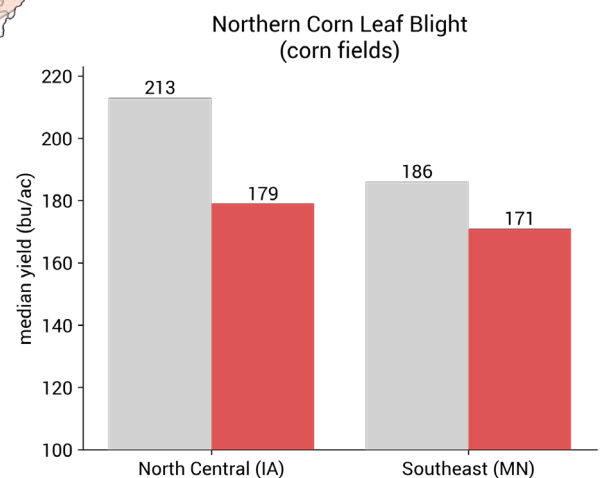
AGRONOMIST NOTES

- Although this is a different pathogen, the behavior for this pathogen is nearly identical to Gray Leaf Spot.

- The highest-risk fields occur in a band through the central part of the Midwest.

- There may be yield opportunities ranging 14-34 bu/ac with more aggressive management in North Central Iowa and Southeast Minnesota.

Diplodia Ear and Stalk Rot

Crop Protection Network

Diplodia Ear Rot (corn fields)

median yield (bu/ac)

233

209

South Central (WI)
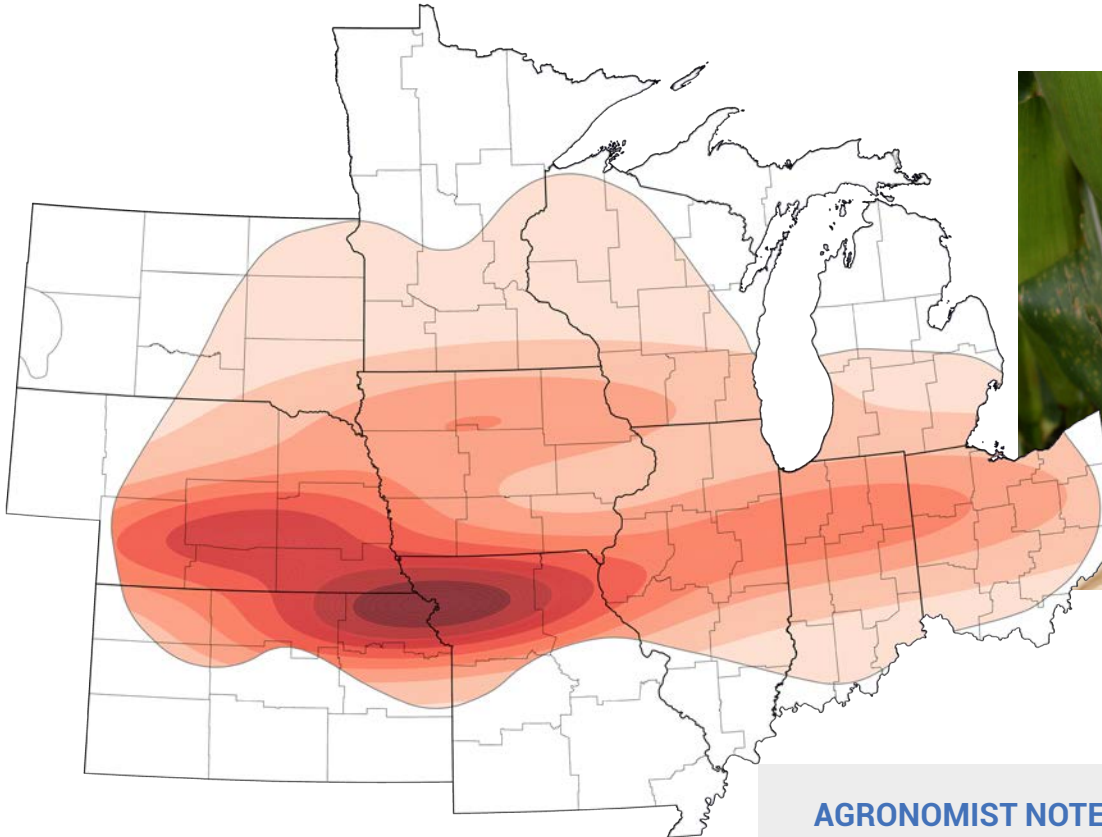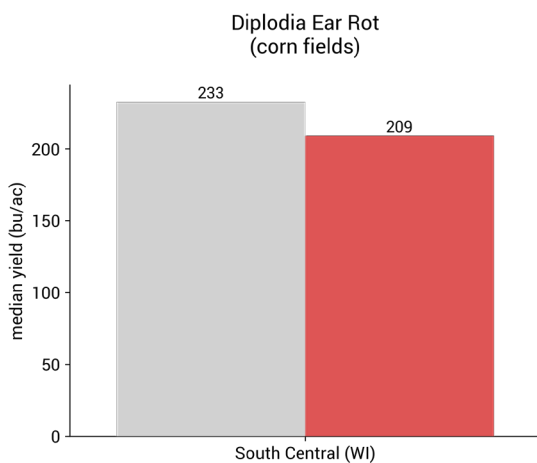
INFECTION TIMING

Early in the growth stages.

TREATMENT

Plant resistant hybrids, and use tillage post harvest to reduce infected residue.

AGRONOMIST NOTES

- Highly localized infections can be hard to predict based on larger-scale weather patterns. We do, however, see a correlation between higher abundances and high summer soil temperatures.

- We expect a small reduction in the overall fields with moderate to high risk for 2024 when compared to 2023.

- In other countries this pathogen is known to produce mycotoxins that contaminate the grain, but this has not yet been observed in the US.

- In 2023 we believe growers may have been under-managing this pathogen in South Central Wisconsin, where we saw nearly 24 bu/ac differences between low- and high-risk fields.

📍 INFECTION SPOT

Roots

Cercospora Blight of Soybean
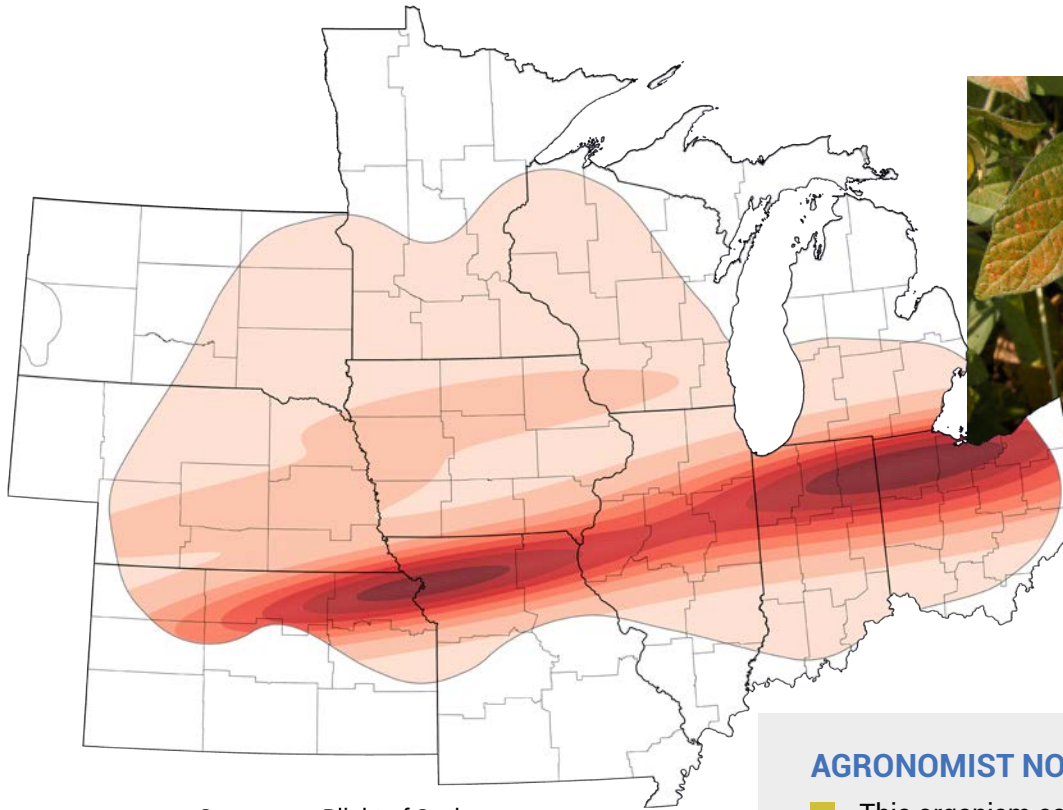
Craig Rau, bugwwod.org

Cercospora Blight of Soybean
(soybeans fields)

median yield (bu/ac) — North Central (IA): 56, 42 — Southeast (MN): 51, 48

📍 INFECTION SPOT

Foliar

CRITICAL INFECTION TIMING

R1
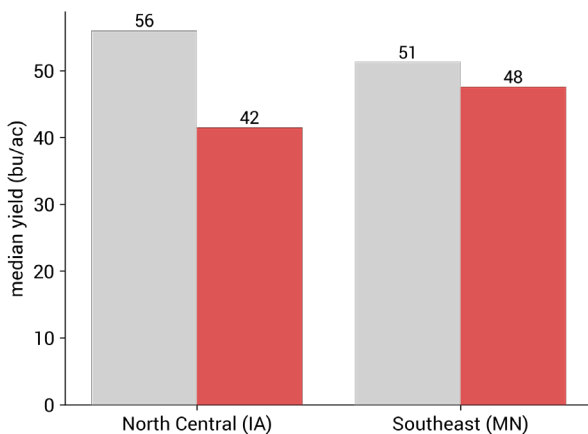
AGRONOMIST NOTES

- This organism causes purple seed stains in soybeans. While there is generally very little yield risk, it can reduce the value of the grain.

- Bronzing of the leaves does not meaningfully reduce the yield, but is often seen on lower-producing fields in North Central Iowa.

TREATMENT

Infections severe enough may require a fungicide application, but is generally not economically feasible.

However, R1-R5 application of foliar fungicides containing QoI fungicide AIs, including azoxystrobin, fluoxastrobin, pyraclostrobin, trifloxystrobin.

Triazole fungicides, including ipconazole, prothioconazole, Tetraconazole, and Myclobutanil, and Tebuconazole.

Products containing multiple modes of action (containing both QoI and triazole actives) are generally the most effective.

Septoria Brown Spot

Crop Protection Network

INFECTION SPOT

Leaf

INFECTION TIMING

Anytime rain creates a splash from infected residue to plant.

TREATMENT

Septoria brown spot typically does not require management because it rarely causes significant losses. Soybean varieties are not available with resistance to this disease, but varieties can vary in their susceptibility. Rotation with non-legume crops and tillage may be beneficial, and foliar fungicides can provide some control under those rare conditions when an application may be warranted.

AGRONOMIST NOTES

- Septoria Brown Spot is one of the most common soybean diseases, but rarely warrants management except for in the northernmost soybean producing areas where late summer nightime temperatures cool significantly.

- Risk is slightly higher in 2024.

- This pathogen rarely causes significant yield loss unless favored by overall wet conditions, and epidemics can happen after heavy rainfall or irrigation.

- Hot, dry conditions can dramatically slow the infection of this pathogen, and generally by August the hot weather has "stopped" disease progression.

Unlocking Your Soil's Biofertility

FOR MAXIMUM YIELDS

These predictive maps provide a forward-looking perspective on soil biofertility measures across the Midwest for the 2024 growing season. At the heart of these insights lies the key to unlocking your field's potential for maximum yield. Your soil's biofertility is crucial for maximum crop results, so there's one solution – run a Complete Bio Panel with Pattern Ag.

Denitrification Potential

Denitrification activity
(corn fields)
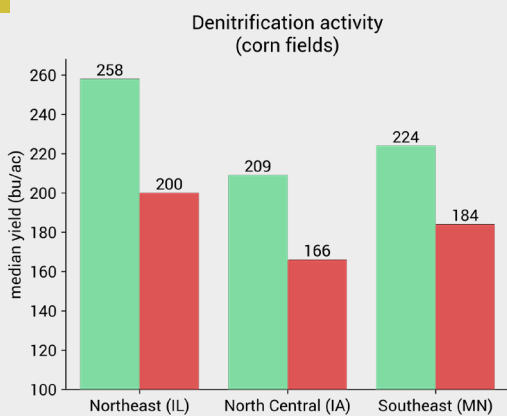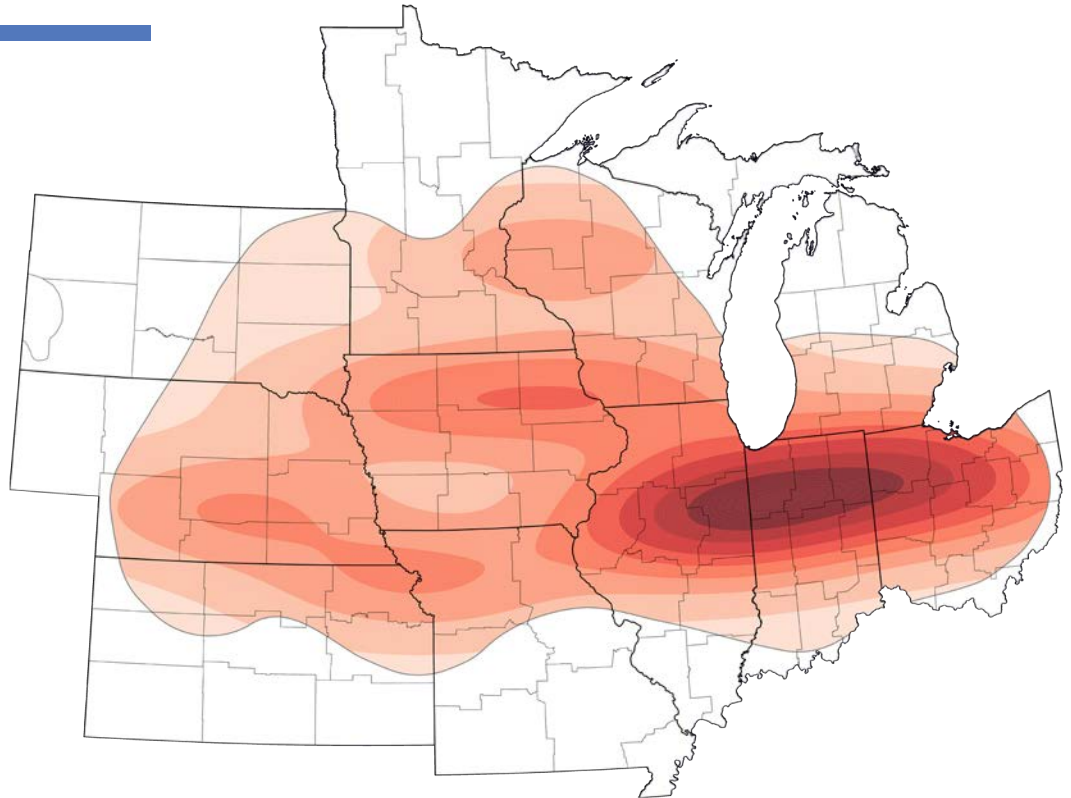
AGRONOMIST NOTES

- Denitrification occurs most commonly on heavy clay, poorly drained soils.

- Denitrification can cause the loss of up to 20% of applied N.

- Denitrification potential measures the ability of a soil to reduce nitrogen to a plant unavailable form, effectively removing N from your field leading to a waste of N inputs. To reduce the impact it is suggested to split nitrogen applications into multiple applications if possible, and/or use a stabilized form of nitrogen to reduce N loss. These forms of nitrogen stabilizers include urease inhibitors, nitrification inhibitors, and slow-release coated nitrogen. The use of any of these three forms of stabilizers will help to lessen the impact of denitrification, but will not cure the denitrification activity of a soil.

TIMING

Moist to wet soils, predominantly in the spring.

TREATMENT

Nitrogen stabilizer, or split fertilizer treatment to reduce the risk of N loss.

Denitrification Activity — no product will directly impact this, but there are "nitrogen stabilizers" that will improve nitrogen use efficiency. Examples include: Urease Inhibitor, Agrotain® by Koch Agronomic Services, Nitrification Inhibitor, N-Serve® by Corteva & Slow Release Coated Fertilizer, ESN by Nutrien.

P Solubilization Potential
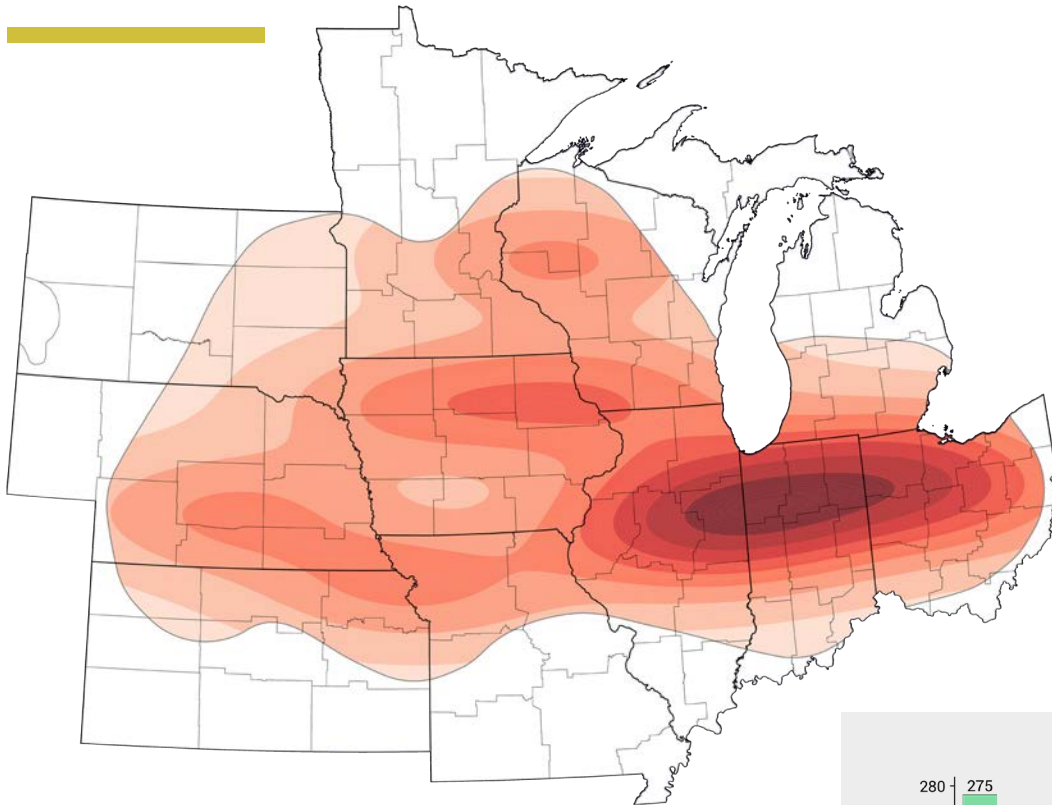
AGRONOMIST NOTES

- Low P availability will show up as stunting, purpling of leaves, or lower vigor during the early growth of a crop.

- At Pattern Ag, we often see a yield linkage both within a field and among fields with this analytic, independent of the total P in the field.

- A number of organisms are associated with P solubilization, and we recommend amending soils where this important component of the community has been lost.

- In the 2023 crop season we found that low levels of beneficial microbes also caused yield reductions. Low levels of P solubilization bacteria and Trichoderma were linked to widespread yield losses across the midwest in both corn and soybeans fields. Yield loss due to low Trichoderma ranged between 9-30 bu/ac in corn and up to 17 bu/ac in soybeans. In corn, low P solubilization was linked to 2-46 bu/ac losses, and 2-32 bu/ac losses in soybeans.

TREATMENT

P Solubilization — AMF inoculating products will improve P solubilization, but there are also products specifically designed for P solubilization. Examples include: BioPath® by Mosaic Biosciences, SOURCE by Sound Ag, BioniQ® by Novozymes, TM FUEL-LINE, TM NUTRIFUEL, TM Nutrifuel Soybean by Meristem, Micro-Cycle by Hefty, Pantego & Rhizolizer by Locus Ag.

P solubilization activity (corn fields)

median yield (bu/ac)

Region	Green	Red
Northwest (IA)	275	231
North Central (IA)	213	199
South Central (MN)	250	220
Southeast (MN)	188	176
South Central (WI)	233	215

P solubilization activity (soybeans fields)

median yield (bu/ac)

Region	Green	Red
North Central (IA)	66	51
Central (IA)	55	52
Southwest (IA)	56	51
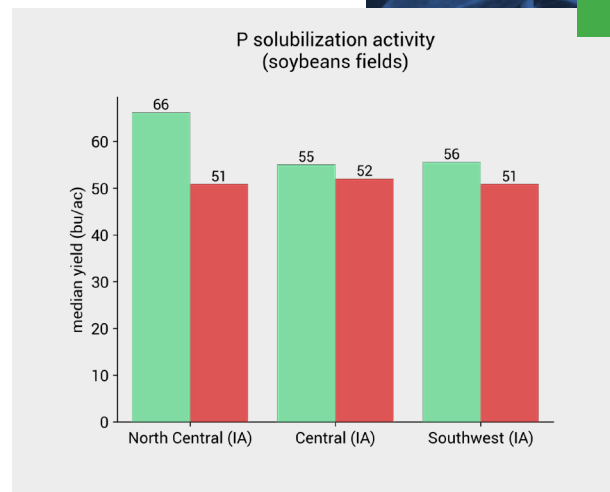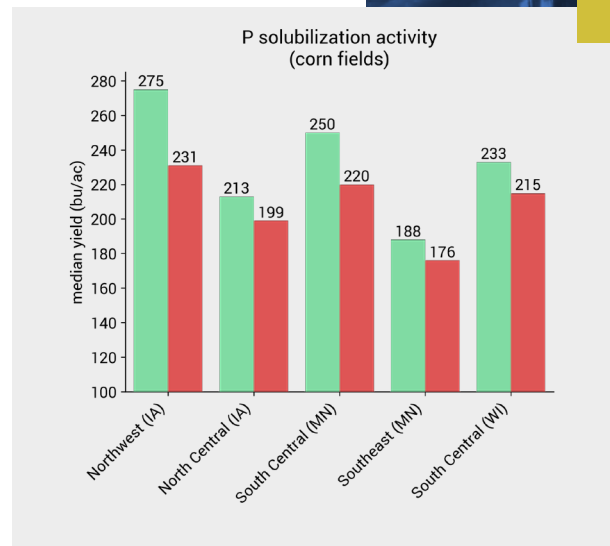
Mycorrhizal Fungi (AMF)
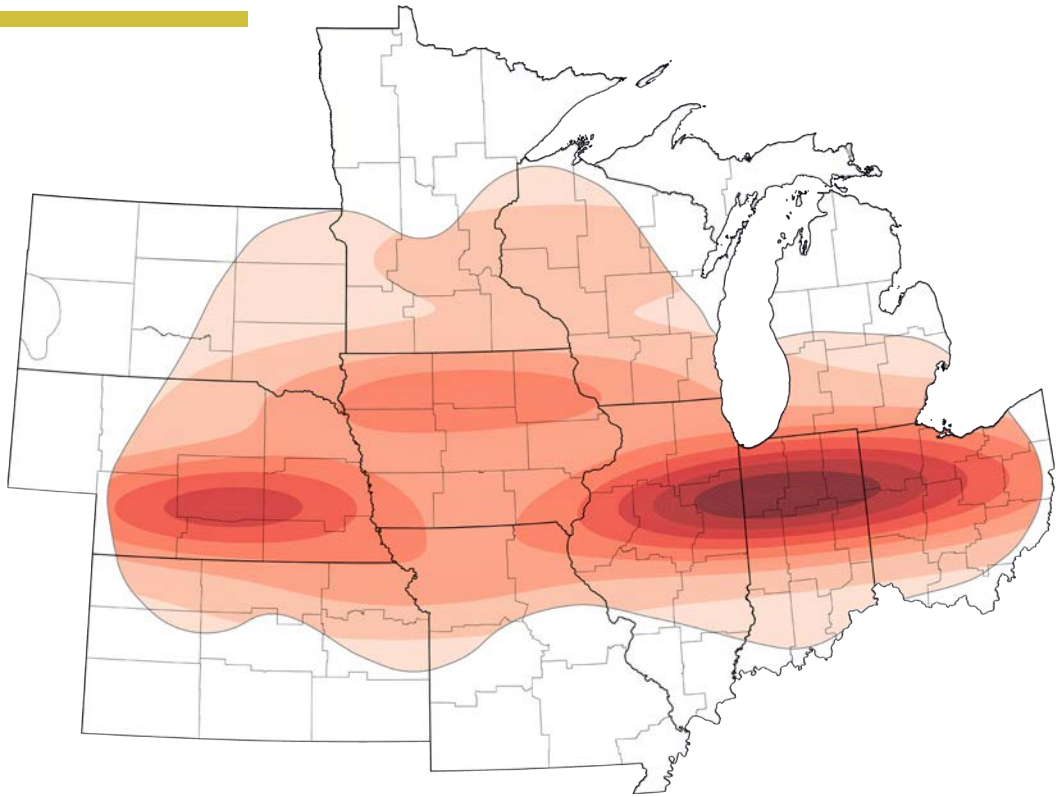
AGRONOMIST NOTES

- AMF is a symbiote forming a beneficial relationship with plant roots. This relationship results in better growth of the plants, with increased nutrient flow and improved drought responses where there is a robust AMF community.

- AMF does not form as strong an association with soybean, so the biggest impact of lower AMF is found in corn fields.

- While tillage induces a loss of AMF in soils that drain well, at Pattern Ag we often also observe low AMF with poorly drained soils, and methods that aerate the soils can assist in higher populations on those types of soils.

📍 INFECTION SPOT

Bonds with roots

TREATMENT

There are a number of AMF products on the market today that are meant for the inoculation of AMF. Examples include Rootella by Groundwork BioAg, MycoApply® & Symvado® by Valent BioSciences, iNvigorate® by AMVAC, Mycomaxx by Farmfungi, Mycormax by JH Biotech, Bio S.I. Agricultural Formula by Bio S.I.

Mycorrhizal Fungi (AMF)
(corn fields)

median yield (bu/ac)

250

202

South Central (MN)
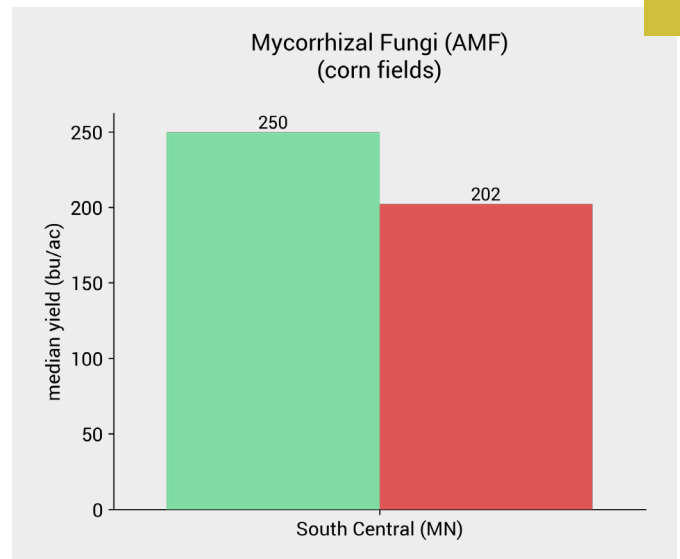
Understanding the yield opportunities in regions:
NORTH-CENTRAL IOWA

At Pattern Ag, we are deeply interested in understanding how pathogens and beneficial microbes impact crop outcomes. So, during the 2023 growing season, we ran trials across 30,000 acres and used our Complete Bio analysis to determine how those risks impacted yield. By comparing outcomes in high-risk vs. low-risk fields, we determined **the yield impact associated with a wide range of pathogens and beneficial microbes.**

We found that elevated pathogen levels and depressed biofertility measures had an outsized impact on yield, **averaging 10-30 bu/ac across the Midwest, with specific regions showing losses over 50-90 bu/ac.** In the chart below, we provide a summary of the pathogens and biofertility measures most heavily impacting yield across the Midwest:

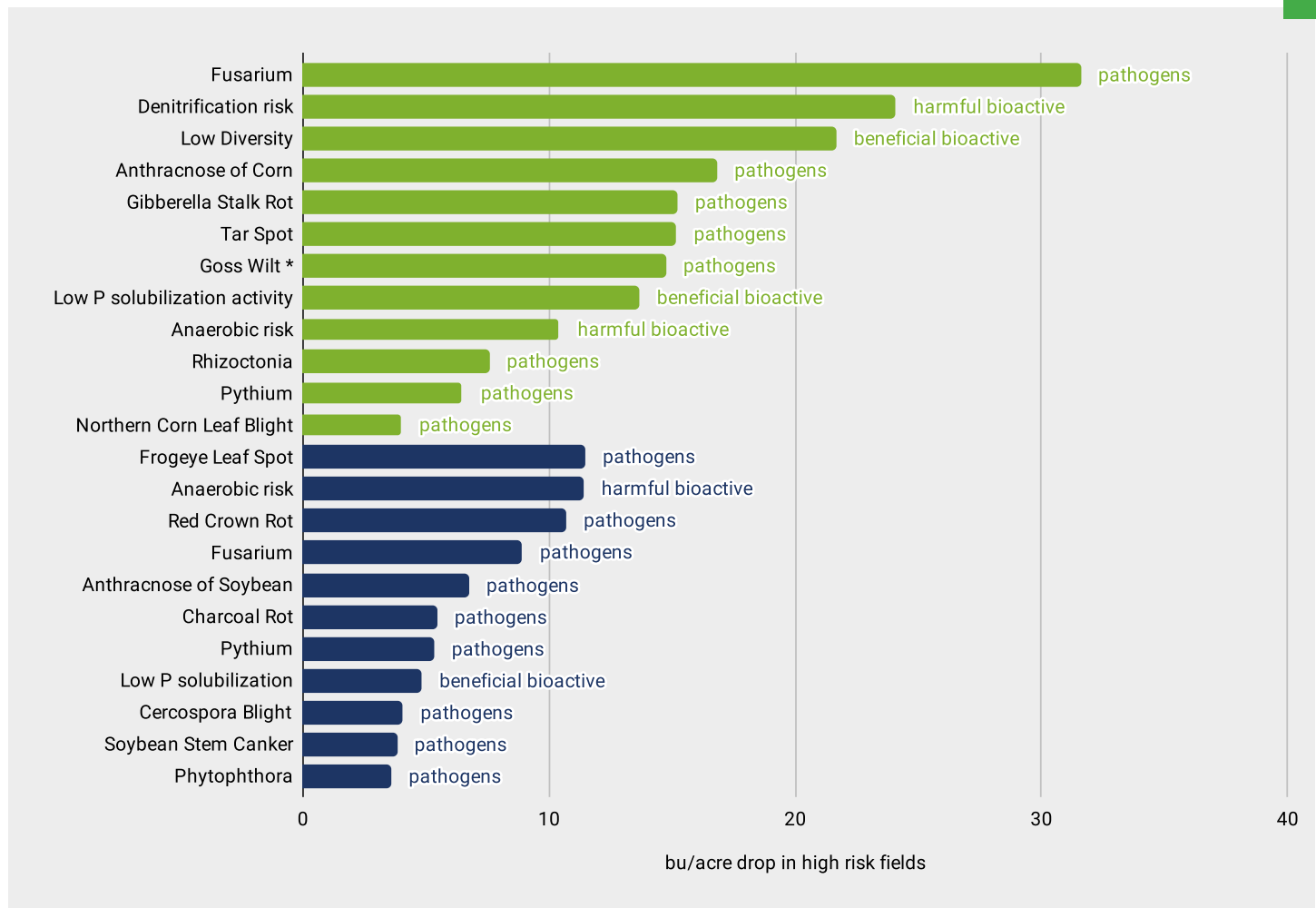| Category	bu/acre drop in high risk fields
Fusarium	pathogens
Denitrification risk	harmful bioactive
Low Diversity	beneficial bioactive
Anthracnose of Corn	pathogens
Gibberella Stalk Rot	pathogens
Tar Spot	pathogens
Goss Wilt *	pathogens
Low P solubilization activity	beneficial bioactive
Anaerobic risk	harmful bioactive
Rhizoctonia	pathogens
Pythium	pathogens
Northern Corn Leaf Blight	pathogens
Frogeye Leaf Spot	pathogens
Anaerobic risk	harmful bioactive
Red Crown Rot	pathogens
Fusarium	pathogens
Anthracnose of Soybean	pathogens
Charcoal Rot	pathogens
Pythium	pathogens
Low P solubilization	beneficial bioactive
Cercospora Blight	pathogens
Soybean Stem Canker	pathogens
Phytophthora	pathogens

bu/acre drop in high risk fields

This analysis shows that what we measure at Pattern Ag predicts significant yield outcomes in the field. For farmers at elevated risk, taking action to reduce these measures would go a long way to boosting their yield potential.

Yield difference between
low and high pressure Fusarium fields
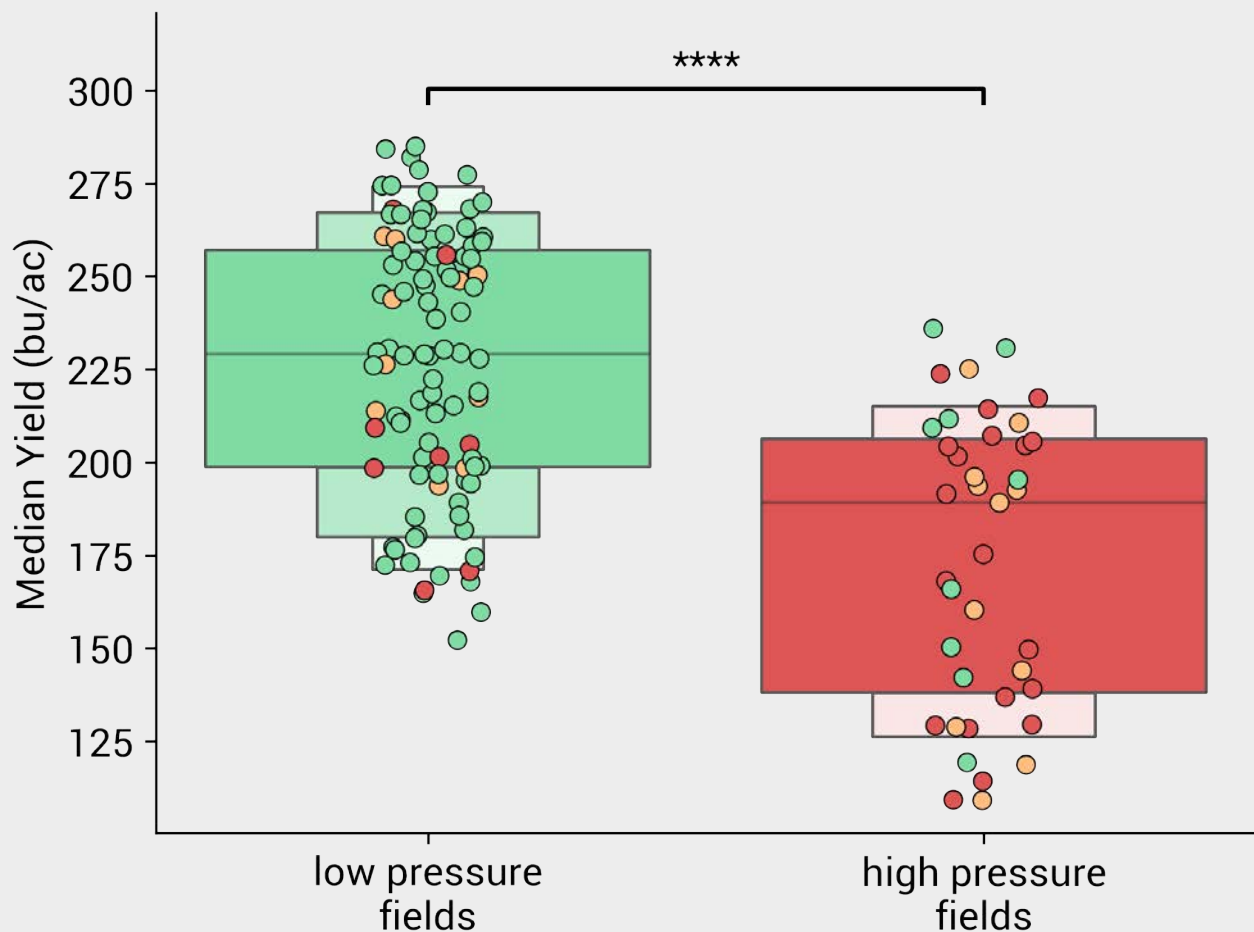
While the above chart looks at the Midwest average, the impact was even more severe in some regions. In one of the more extreme cases, we saw a yield impact in excess of 90 bushels for fields with elevated Fusarium in North Central Iowa — in this region, the average yield from our trials was roughly 200 bu/ac, but fields **low in Fusarium averaged around 240 bu/ac, while fields high in Fusarium averaged only 150 bu/ac.** From an agronomic perspective, this large shift is likely the result of pathogen stacking in those Fusarium fields. We would expect Fusarium to hit the plant earlier in the season and compound the impact of the other pathogens as the season progresses. In this case, there was also elevated pressure from **Northern Corn Leaf Blight, Tar Spot, and Anthracnose of Corn. That means that while opportunities for higher yield are significant for fields currently undermanaged for Fusarium**, the full potential is realized by managing all the high-risk pathogens in a field.

By taking action on these sources of yield loss, growers can increase their yield potential in the next growing season. Pattern Ag can help you identify and address these potentially hidden threats.

By taking action on these sources of regional yield loss, growers in these regions can increase their yield opportunities in the upcoming growing season.

Digging Deep into Field Research:

PATTERN AG GROWER'S INITIATIVE LEADS THE PREDICTIVE AG REVOLUTION

Pattern Ag's mission is to unlock biologically powered agriculture. We aim to predict next season's opportunities and risks by understanding how field biology influences farm outcomes. But to answer this question, we need high-quality agronomic and biological data from across the Midwest.

This is why Pattern Ag has teamed up with forward-thinking growers to run various trials and studies in commercial fields. These studies help us identify hidden sources of yield loss, develop powerful predictive models, and improve the accuracy of our analytics. Join us as we share what we've been up to with the Pattern Ag Grower's Initiative over the last year!

PROGRAM STATS:

2023 ACRES IN PROGRAM:

Corn: 5,185 acres
Soybean: 6,056 acres

Samples collected: 1,715

Number of fields: 124
Number of growers: 35
1 sample = 12 Aggregated 6" cores

PATTERN AG PANELS RUN:

- Pattern Ag Complete Bio, which includes pests, soil-borne diseases, foliar diseases, and macro- and micro-nutrients.

- Leaf tissue analysis for pathogen expression
Leaf tissue analysis for pathogen expression.

200 km

2023 Crop
- corn
- soybean
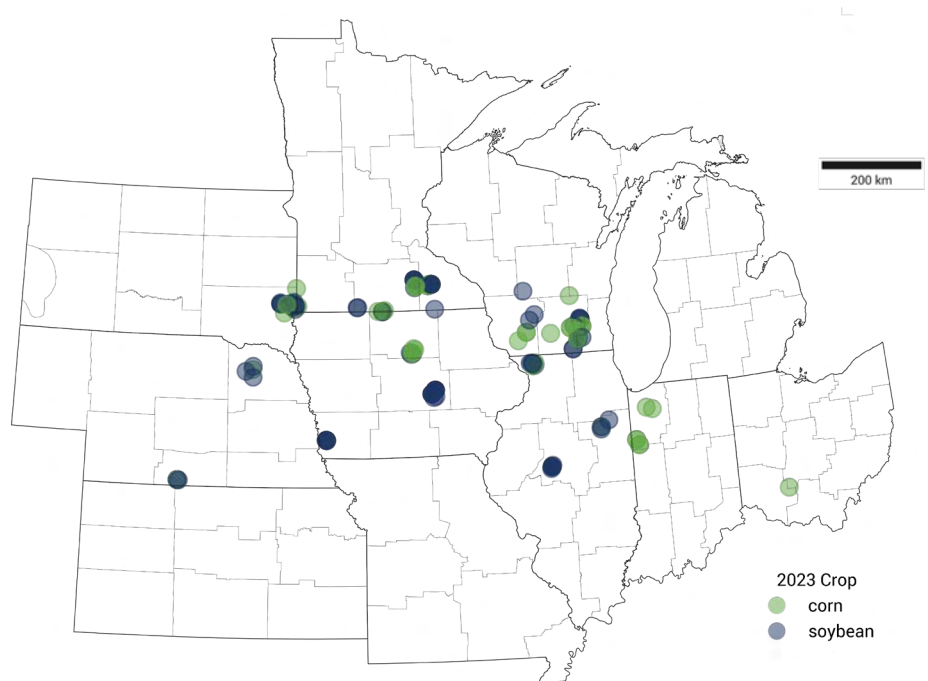
PROGRAM BACKGROUND

Before planting, fields were sampled using Pattern Ag's standard 10-acre density. Samples were then analyzed using Pattern 360. In mid-September, scouters were sent to each field to visually inspect and diagnose pathogen-related damage. Scouters visited up to 6 locations on average per field and up to 15 locations in some cases, depending on field size. In addition to visual diagnosis, scouters collected plant tissue from each location. These clippings were then sent to the Iowa State Pest and Insect Diagnostic Clinic (ISU PIDC) for lab diagnosis.

In 2022, we focused on SDS-related damage in soybeans and asked scouters to only evaluate plants for SDS expression.

This year, we expanded our protocol and asked scouters to assess for any pathogen expression in corn and soybeans.

PERCENT OF TIME THE SCOUTER'S IN-FIELD DIAGNOSTIC CORRECTLY IDENTIFIES A PATHOGEN:

Chart 1 (Soybean) — Y-axis: PERCENT OF TIMES SCOUTER DIAGNOSIS WAS CORRECT (VERIFIED BY LAB); X-axis: DIAGNOSIS (# OF TIMES SEEN BY SCOUTER)

- NO PATHOGENS (N=143): 57.2%
- WHITE MOLD (N=15): 62.5%
- FROGEYE LEAF SPOT (N=44): 50.0%
- CERCAPORA LEAF BLIGHT (N=8): 33.3%
- SEPTORIA BROWN SPOT (N=66): 20.8%
- BACTERIAL BLIGHT (N=21): 19.2%
- SOYNEIN VEIN NECROSIS VIRUS (N=12): 16.7%
- INSECT FEEDING (N=44): 6.7%

Chart 2 (Corn) — Y-axis: PERCENT OF TIMES SCOUTER DIAGNOSIS WAS CORRECT (VERIFIED BY LAB); X-axis: DIAGNOSIS (# OF TIMES SEEN BY SCOUTER)

- NO PATHOGENS (N=143): 57.2%
- TAR SPOT (N=20): 61.9%
- DOWNY MILDEW (N=33): 51.4%
- NORTHEN CORN LEAF BLIGHT (N=10): 10.0%
- INSECT FEEDING (N=44): 6.7%
- GRAY LEAF SPOT (N=53): 3.5%

CORN: DIAGNOSTIC RESULTS

The ways diseases present in the fields make it very challenging to accurately diagnose the pathogen on the ground. Diseases often look similar to each other and physical damage, such as wind or heat stress. Shown are the percent of times when a scouter noted a disease and it was independently confirmed by the ISU PIDC lab.

> *Using scouting as your only diagnostic tool is difficult. Adding Pattern Ag's biological analysis gives you the confidence that what you see is actually what you're up against.*

SOYBEAN: DIAGNOSTIC RESULTS

In soybeans, Septoria Brown Spot, SDS, and Frogeye Leaf Spot were the most common diagnoses. Scouters correctly diagnosed Septoria Brown Spot 20% of the time, and commonly misdiagnosed as Downy Mildew or Frogeye Leaf Spot. Frogeye Leaf Spot was correctly diagnosed 50% of the time and widely mistaken for Downy Mildew. No SDS-related damage was found by the ISU PIDC lab.

SCOUTING IS HARD TO GET RIGHT

GRAY LEAF SPOT

Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

GOSS' WILT

Adam Sisson, Iowa State University, Bugwood.org
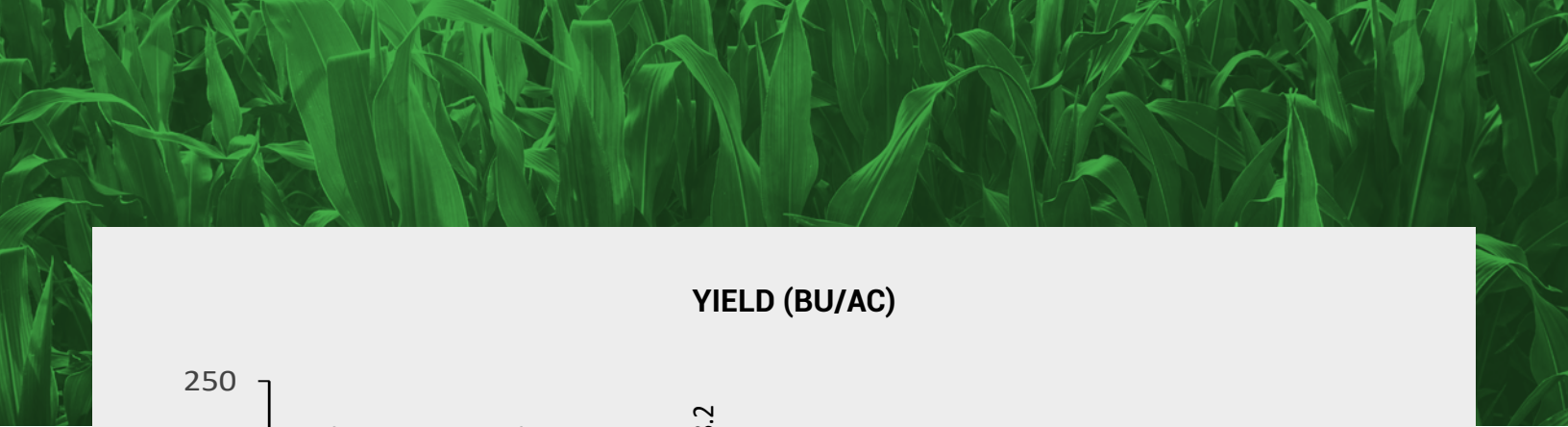
NORTHERN CORN LEAF BLIGHT

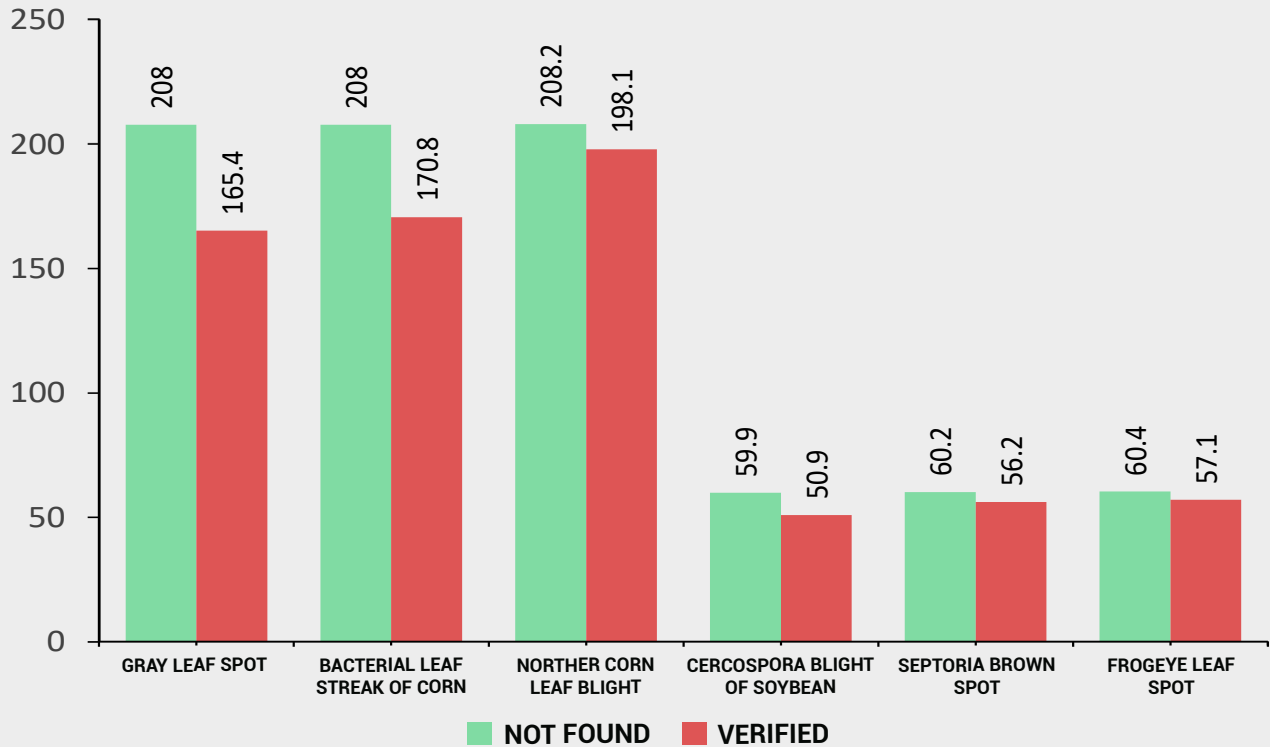*Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org*

BACTERIAL LEAF STREAK OF CORN

Vinicius Garnica, Bugwood.org

YIELD (BU/AC)

Chart legend:
- **NOT FOUND** (green)
- **VERIFIED** (red)

Pathogen	NOT FOUND	VERIFIED
GRAY LEAF SPOT	208	165.4
BACTERIAL LEAF STREAK OF CORN	208	170.8
NORTHER CORN LEAF BLIGHT	208.2	198.1
CERCOSPORA BLIGHT OF SOYBEAN	59.9	50.9
SEPTORIA BROWN SPOT	60.2	56.2
FROGEYE LEAF SPOT	60.4	57.1

YIELD LINKAGES

In terms of yield linkages, we were able to identify 6 foliar pathogens that resulted in yield loss amongst the fields scouted. Average yield losses ranged between 3 and 43 bu/ac. Bacterial Leaf Streak of Corn was verified in less than 5% of samples, but those samples had a severe diagnosis, and in one case it co-occurred with Tar Spot. Gray Leaf Spot is also a pathogen that often is not a significant yield loss, but in extreme cases can result in a 20% yield loss. For our fields, this pathogen often showed up with other pathogens, including Tar Spot and Bacterial Leaf Spot, which amplifies the yield loss associated with that pathogen.

Are you interested in being part of the Grower's Initiative? Participating growers get a customized field report and yield-linked analytics tailored to their fields. To find out if you qualify for the 2024 Grower's Initiative, contact *agronomy@pattern.ag* or *reach out to your sales representative.*

Healthy Soils Maximize Yields:

HOW RETHINKING THE 'HEALTH' OF YOUR SOIL CAN HELP YOU MAXIMIZE YIELD AND PROFITABILITY

INTRODUCING THE SOIL PRODUCTIVITY INDEX

At Pattern Ag, we believe that healthy soils are efficient soils - which means sustainably producing maximum potential output (yield) per unit of input (fertilizer, chemicals, etc.) But this definition begs a few questions:

- What is the full yield potential for a given field?
- And what are the gaps we need to close to achieve that full potential?

Our answer was to establish what we call a 'Soil Productivity Index' (SPI), which we believe is the most accurate and actionable measure of soil health and productivity available today. The SPI is a comprehensive measure of how productive we believe a current soil environment will be relative to the full potential it could achieve if managed and optimized for maximum performance and sustainability. The SPI predicts how well your field will perform today and provides a prioritized list of issues ('SPI Roadmap') that can be addressed to move your field closer to its full potential.

We developed the SPI by assembling a comprehensive set of soil measures (physical, chemical, and biological) anchored by Pattern Ag's industry-leading soil biology analysis (millions of DNA reads from the billions of microorganisms per sample). We then added in broad geophysical measurements, like soil type and climate division, along with a dozen chemistry markers, like pH, CEC, macro- and micro-nutrient profiles. Combining all that with yield data, we created a comprehensive measurement of each field's soil potential, benchmarked against similar soils in that climate zone. This tells a farmer where they are on their soil health journey. It also tells them what they could achieve by improving their soil and predicts their yield impact.

In this way, the SPI addresses many of the shortcomings of existing soil health analyses. While well-intentioned, many soil health techniques try to measure biology through indirect means, as opposed to direct biological analysis. Moreover, notions of what a 'healthy soil' looks like are based on narrow academic opinions rather than outcome-based data from commercial fields. Lastly, most soil health measures are highly generalized, making them hard to apply across the Midwest's broad range of growing environments. Because of this, these existing measures are difficult for farmers to interpret and lack a tie to direct agronomic recommendations that will improve field performance and farm profitability.

To explain how the SPI differs from soil health insights you may be familiar with today, see Table 1 below.

| Traditional Soil Health	Pattern Ag SPI
Unclear ties to yield: Many soil health metrics have little or no consideration for yield potential or the productivity and efficiency of a given soil. They are focused on abstract measures that may or may not be tied to positive outcomes for the field or the farmer.	**Yield focused:** SPI identifies the important soil characteristics directly tied to the yield outcomes in your field. Using this, we can estimate your field's yield potential and quantify your current yield gap so you can make the right decisions to maximize sustained yield potential.
Reactive: Often, soil health metrics are used to track progress in the past but provide little insight into the key next steps to improve field productivity and yield next season.	**Predictive and actionable:** The SPI predicts the productivity of your field next season and provides a roadmap of recommendations you can follow to improve your soil's potential.
Generic: Most soil health measures take a one-size-fits-all approach to evaluating a field. With the massive variation in soil type and climate, it's impossible that these measures get the right answer for fields across the varied environments of the Midwest.	**Region-specific:** Different soil types and climate zones will have varying conditions and yield potential. The SPI is tailored to your specific region, so the insights and benchmarks apply to the specific conditions of your field and soil type.

Table 1. Comparison of traditional "soil health" analytics with Pattern Ag's new SPI insight.

RELATIVE POTENTIAL: NOT ALL FIELDS ARE CREATED EQUALLY

Every sample that gets the Pattern 360 receives an SPI score between 0-100%. This score predicts the soil productivity for the next growing season based on the physical, chemical, and biological signatures in the soil. That score is then tied to a predicted yield for the field based on soil type and climate zone. The maximum score (100%) represents a highly productive field already at or near its maximum yield potential for the region. Lower scores represent fields with issues that may yield below the region's potential if management actions are not taken.

It's worth noting that some soils and climates are inherently more productive than others. Just because a field is yielding well doesn't mean it's at the high end of its potential or productivity score — despite good performance, there may be significant room for improvement. Likewise, just because a field is lower yielding doesn't mean it's under-performing its potential — it may already perform as well as possible given its soil type and climate conditions. Figure 1 demonstrates this dynamic — A mollisol in Northeast Illinois may be predicted to yield ~210 bu/ac but receive a 19% productivity score if its regional potential is closer to 280 bu/ac. In the same way, an Inceptisol in Northwest Missouri with a predicted yield of 210 bu/ac may be near the high end of its regional potential and therefore warrant an 81% productivity score.

The SPI is designed to fall between 0-100% and is not a prediction of absolute yield but rather an indication of how close or not we think your field is to its specific yield potential (represented by 100%). This way, the soil productivity and yield ranking align well with each other. Growers receive an understanding of the **current soil productivity potential and the path to a healthier soil that produces more yield.**
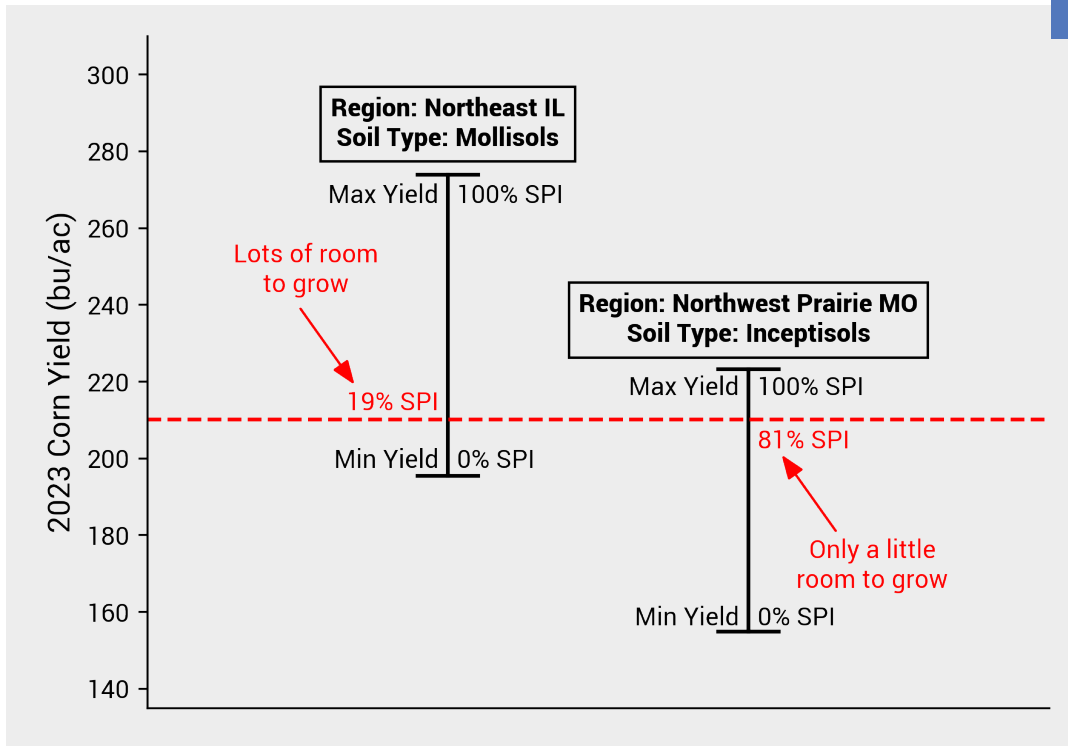
FIGURE 1. *PAR Region Comparison*

Regional Patterns in Yield

ACCOUNTING FOR CLIMATE

By comparing fields within their respective climate division we remove the broadscale yield shifts due to climates or weather conditions. Note that this does not remove yield impacts from more localized weather events – such as an extreme hail event.

KNOWING YOUR SOILS

We know not all soils can carry the same fertility and yield. In regions with highly diverse soil soils, we often see variation in soil type within a single field, which can explain within-field yield dynamics. We provide scores based on the dominant soil type within each sampling zone to account for this, allowing for different soil classifications across an entire field.

Putting the SPI into Action

CASE STUDY WITH A GROWER'S INITIATIVE PARTICIPANT'S SOYBEAN FIELDS

So, how does the SPI perform when compared to the actual yield? Here, we show the index in fields belonging to one of our 2023 trials in Central Iowa. These fields were sampled in early June 2023 (pre-planting), and the results were used to determine their predicted 2023 SPI scores, which we then compared to the yield obtained during the Fall 2023 harvest. Figure 2 below shows the field results for this PAGI grower.
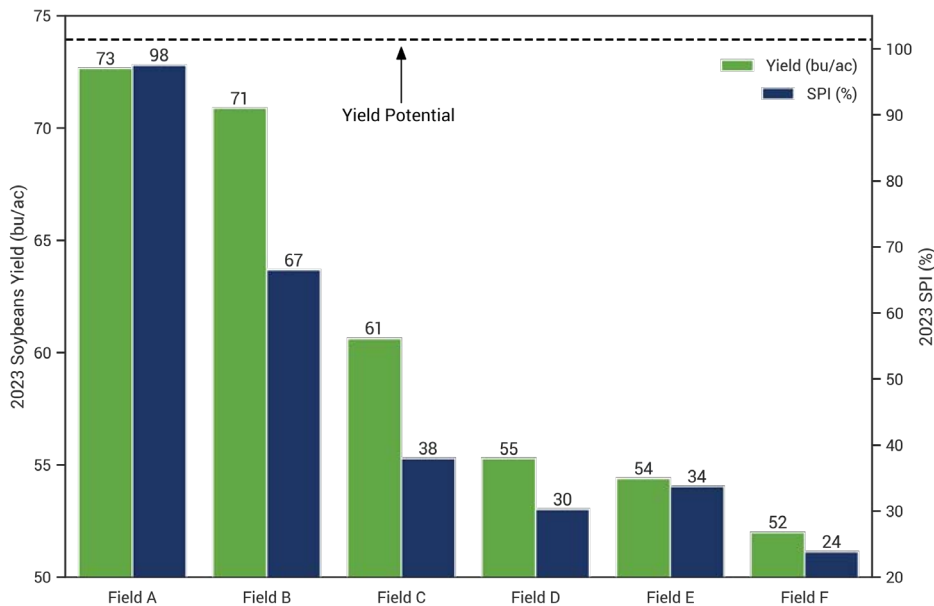
FIGURE 2. *Actual 2023 soybeans yield compared to predicted 2023 SPI scores for fields belonging to one 2023 Grower's Initiative operation. Each field has a light and dark bar associated with it that captures the measured yield (bu/ac) and predicted SPI (%), respectively. All of the fields in this analysis are located in Central Iowa and have soil types that are predominately Mollisols.*

We see a strong agreement between our predicted SPI score rankings and the actual yield observed. There is, however, one outlier: Field E. For this field, the yield was slightly lower than expected based on the SPI score – so what could have caused this? Something specific likely caused a drop in yield that was not captured by the parameters of our model – such as an extreme weather event or perhaps undermanagement of a disease that might not typically be a huge yield-robber for this region but happened to express on this particular field. For example, this field was at high risk for Anthracnose of Corn, Charcoal Rot, Gray Leaf Spot, and Goss's Wilt, which were not important for yield outcomes in this broader region but certainly could have impacted this particular field.

The opposite is also possible: Instances of higher-than-expected yield compared to corresponding SPI scores. This would indicate a grower overcoming any inadequacies inherent to their soil through management actions that improved the yield outcome. That is, ultimately, exactly how we have envisioned growers using this new SPI analytic. It is designed to work with other Pattern Ag analytics, highlighting the most important soil characteristics and management actions most likely to improve yield outcomes in each field.

STAY TUNED AS WE ROLL OUT THESE INSIGHTS IN YOUR REGION!

# Unveiling Pattern Ag's Impact

THROUGH CUSTOMER SUCCESS

____

The real-life experiences of farmers often embody the heart and soul of agricultural innovation.

This section highlights Pattern Ag's Customer Stories – narratives of resilience, progress, and the pursuit of excellence. As they faced obstacles in their fields, they sought a partner to unlock untapped potential. We'll dive into the challenges these farmers encountered, the moment they decided to harness the power of Pattern Ag, and the results that sprouted from their journey. From leveraging data insights to implementing recommendations, these stories reveal how Pattern Ag's predictive technology is not just a game-changer; it's a growth accelerator for modern agriculture.

>$100 / ac Savings on Seed and Insecticide Using Pattern Ag's Corn Rootworm Analysis

JASON ORR, ORR FAMILY FARMS, ROWLEY, IOWA

2024 Corn Rootworm Risk
Orr Family Farms
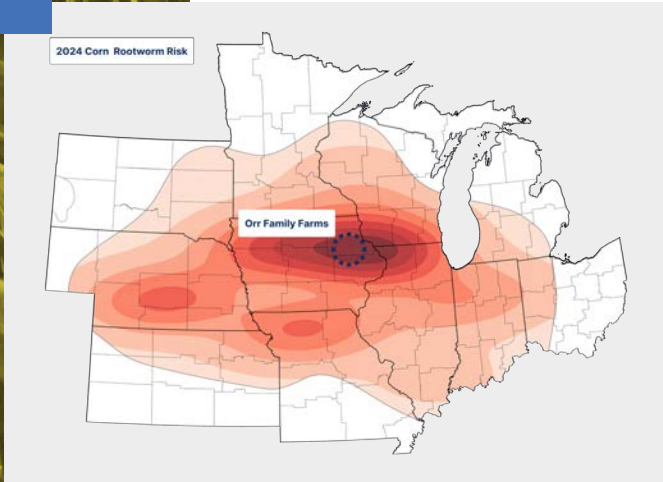
*Orr Family Farms is located in Northeast Iowa, and like **most farms in that region, they grow continuous corn, living with the constant threat of Rootworm yield loss.** Traditional management practices suggest planting a hybrid with a rootworm trait stack and, for added protection, applying an insecticide in-furrow at planting.*

THE OPPORTUNITY:

Jason Orr, the 5th generation leader of Orr Family Farms, knew there was an opportunity to save significant money on their seed and insecticide spend if they could identify the true risk of rootworm feeding in each field. *Planting non-traited or non-GMO hybrids could save them over $70 / ac, and dialing back their insecticide spend was worth another $30 / ac.* In addition, certain non-GMO varieties could be sold for a significant premium.

POTENTIAL SAVINGS	VALUE
Plant conventional or non-GMO seed	$70+ / ac
Reduce insecticide spend	$30 / ac
TOTAL	*$100+/ac*

HOW PATTERN AG HELPED:

Jason started his first year with Pattern Ag by running a trial on ~400 acres. He used Pattern Ag's Pressure Panel to identify the rootworm risk on every acre. Using that information, he could reduce his insecticide application on the fields that came back with low Rootworm egg pressure and, therefore, low rootworm risk.

After performing root digs and comparing yields across those 400 acres, Jason found that the Pattern Ag rootworm analysis had correctly identified the low-risk fields — the areas where he had reduced insecticide saw no material root feeding or negative yield impact.

Expanding on this trial, the next year, Jason used Pattern Ag's rootworm analysis on every acre he farms to identify the low-risk fields where he could plant non-GMO corn. Because of Pattern Ag testing, the farm has successfully integrated non-GMO corn into its rotation, with 75% of its seed being non-GMO. This shift and reduced application of insecticides have helped them save more than $100 / ac per year while growing a more valuable and profitable non-GMO crop.

Boost Yield by 20+ bu/ac with the Right Biofertility Products

CLINT OSBORNE, MIDWEST AG CONSULTING, LEXINGTON, NE

Midwest Ag Consulting, run by Clint Osborne, offers agronomic advisory and related services in Northeast Nebraska. As a farmer, Clint validates products in his fields before recommending them to customers, and he is a big believer in the potential for biological products to boost yield and reduce crop losses.

THE OPPORTUNITY:

In the fall of 2022, Clint ran a Pattern analysis and discovered low levels of Arbuscular Mycorrhizal Fungi (AMF) in one of his fields. Low levels of AMF have been associated with a significant yield drag for corn, and Clint was interested in correcting this problem in his field.

THE SOLUTION:

Clint identified Mycomaxx (from New Age Farming) as a solution to the low levels of AMF. Mycomaxx is a mix of AMF species that are known to extend root structure, help the plant acquire key resources, and free up available nutrients in the soil. Clint applied Mycomaxx in-furrow to part of his field in the spring of 2023, and he tracked performance throughout the season.

"No mycorrhiza added on the left; mycorrhiza added on the right. Whole field was soybeans year before. Same hybrid and plant date. Healthier plants on right, and the ground was easier to disk rip." — Clint Osborne

In addition to visible signs of plant health and vigor in the treated plot, he found a >20 bu/ac yield advantage at harvest.

Pattern Ag Takes Center Stage:

MAKING WAVES IN 2023 NEWS, CONFERENCES, AND PODCASTS

PODCASTS

BUSINESS OF AGRICULTURE PODCAST - PREDICTIVE AGRONOMY THE LAST FRONTIER: SOIL
https://podcasts.apple.com/us/podcast/the-business-of-agriculture-podcast/id1291008696

FARM PROGRESS PODCAST - TURNING DNA INTO AN EARLY WARNING SYSTEM FOR CROPS
https://www.farmprogress.com/crops/turning-dna-into-an-early-warning-system-for-crops

FARM TANK PODCAST
https://www.farmtank.com/podcast/your-outsourced-ag-cto-featuring-pattern-ag/

VIDEO

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Plowing Through 2023

UNEARTHING A YEAR OF ACHIEVEMENTS

Pattern Ag's Memphis Lab:
SPEEDING UP RESULTS & EXPANDING REACH

Pattern Ag has opened their doors to a cutting-edge soil processing lab in the heart of Memphis, Tennessee. This strategic move aims to propel the company's expansion and enhance operational efficiencies. By establishing a presence in this centralized location, **Pattern Ag** is set to significantly reduce result times and streamline its processes, ultimately delivering quicker data-driven insights to its customers. This new facility marks another milestone in the company's growth.

Pattern Plants Roots in Brazil's Agriculture Landscape

At the beginning of 2023, **Pattern Ag** officially opened its state-of-the-art lab in Brazil, marking a significant milestone in collaborating with Lavoro, Brazil's largest agricultural retailer. This partnership aims to revolutionize farming practices and enhance crop yields. **Pattern Ag** has already sampled ~98,000 acres, setting the stage for innovative solutions that promise to reshape the future of Brazilian agriculture.

Pattern Ag

The Predictive Ag Company