Science Societies

Tar spot: A new fungus amongus

By Susan Winsor

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Tar spot fungus has small, raised, black spots irregularly scattered across upper and lower corn leaves from the middle toward the leaf tip. It may be surrounded by a circular brown "fisheye" halo. Photo courtesy of Damon Smith, University of Wisconsin.

Tar spot fungus is a new reason to stay on your corn-scouting toes, especially if you're in the central Corn Belt. It was first found in northern Illinois and Indiana in 2015 before spreading to 12 other states and one Canadian province. Corn yield losses range from 20 to 60 bu/ac, and tar spot can also trigger complications such as lodging. The article will tell you what to look for as well as provide prevention and management tips.
Information herein comes from members of The Crop Protection Network, a collaboration of 35 U.S. and Canadian plant pathologists. Special thanks to Michigan State University, Ontario Ministry of Agriculture, Purdue University, and the Universities of Kentucky, Iowa, Minnesota, and Wisconsin–Madison.

Tar spot fungus is a new reason to stay on your corn-scouting toes, especially if you're in the central Corn Belt. It was first found in northern Illinois and Indiana in 2015 and then spread to much of Michigan, Wisconsin, and Iowa as well as parts of Minnesota, Florida, Georgia, Kentucky, Missouri, Nebraska, New York, Ohio, Pennsylvania, and Ontario. Tar spot continues to spread to new counties in each state. Corn yield losses range from 20 to 60 bu/ac, and tar spot can also trigger complications such as lodging.

Weather is a key driver. Environmental factors that can increase disease risk once the inoculum is present are an average of 7 hours of daily leaf wetness, moderate temperatures, 10 to 12 foggy days per month, and monthly rainfall of at least 5.9 inches.

In Mexico, Central America, and parts of South America, where it's existed since the early 1900s, tar spot is favored when temperatures are 60–70°F, relative humidity is above 75%, and there is least seven hours of moisture on corn leaves.

These conditions characterize the U.S. regions first hit the hardest with tar spot in 2018 in the region around Lake Michigan. In 2021, as tar spot continued to spread, favorable conditions in southwest Indiana river bottoms and areas with heavy rain have now also experienced severe disease, says Darcy Telenko, Purdue University assistant professor and Extension specialist in the Department of Botany and Plant Pathology.



Tar spot is named for its small, raised, black spots (0.1–0.2 inches) (also known as stromata), irregularly scattered across upper and lower corn leaves. Photo by Ed Zaworski, Bugwood.org.

"For example, northern Indiana has had tar spot issues since 2018 where that portion of the state experiences long periods of leaf wetness due to the lake-effect weather. Whereas in 2021, not only did northern Indiana have a severe tar spot epidemic, but also pockets in southwest Indiana. Alternatively, where there was a band of dry conditions in the middle of the state, tar spot had little to no impact on corn."

Some hybrids are noticeably more vulnerable to tar spot, but none are completely resistant. This fungus, *Phyllachora maydis*, can reduce ear weight and kernel fill. If infections start early, corn plants can shut down early. This can lead to lodging and lower silage corn feed quality by reducing moisture and total digestible nutrients (TDN). No mycotoxins have been reported with tar spot infections.

U.S. regional climates, fungal populations, hybrids, and cropping systems likely create tar spot variants and characteristics different from those in Mexico and South America, says Martin Chilvers, Michigan State University associate professor of plant pathology. For example, tar spot in Mexico and Latin America is thought to be comprised of two fungal pathogens, but only one is manifested in the U.S.

What to Look For

Tar spot is named for its small, raised, black spots (0.1–0.2 inches) (also known as stromata), irregularly scattered across upper and lower corn leaves. They protrude to the bottom side, Michigan's Chilvers says. They can form on lower or upper corn leaves and on one or both sides of green tissues. In severe cases, the spots can even appear on husks and leaf sheaths.

Tar spot can form on any leaf tissue, rarely on stalks, and sometimes on tassels, Chilvers says. A tar spot may be surrounded by a circular brown halo up to 0.4 inches (1 cm) in diameter, producing a fisheye appearance, especially on healthy leaves, Indiana's Telenko says.

In the U.S. and Ontario, tar spot is often found during or after silking through to late grain fill (R1–R6). But symptoms have appeared in the U.S. as early as the third-leaf (V3) growth stage on volunteer corn.

Irrigated corn is at much greater risk of yield losses than non-irrigated corn in dry years. It takes two to three weeks from when spores are released from infected debris until tar spot symptoms develop on corn. After infection, new stromata form in infected tissue in 12 to 15 days. Favorable conditions can prompt multiple-spore-release events and infection cycles through a growing season.

Like other corn pathogens, the tar spot fungus overwinters in corn residue and requires a living host to grow and reproduce. Freezing temperatures are no threat.

The Crop Protection Network, a collaboration of 35 university plant pathologists, has a helpful illustrated guide on how best to scout for tar spot at **https://bit.ly/34gwFMM**.

Don't Forget about Other Corn Diseases

As serious as tar spot is, don't forget about other corn leaf diseases that pose serious threats to corn yields: grey leaf spot, northern leaf blight, Gibberella ear rot, bacterial leaf streak, and anthracnose stalk rot. Gibberella ear rot still causes big problems in many states, and northern corn leaf blight resurgence is causing up 60 bu/ac yield losses and more at many Canadian locations, says Albert Tenuta, field crop plant pathologist for Ontario Ministry of Agriculture, Food and Rural Affairs.

How to Distinguish Tar Spot from Southern Corn Rust

- Tar spots are raised and firm, mostly smooth on their surface, and the spots do not rub off or break open (as do southern corn rust pustules), says Dean Malvick, University of Minnesota Extension plant pathologist.
- Rust is initially an orangish color, advancing to a more blackish hue when it can be confused with tar spot. The leaf epidermis bursts through the leaves in tar spot but not in rust, says Martin Chilvers, Michigan State University associate professor of plant pathology. Questions can easily be settled by sending samples to your state's lab.

How to Distinguish *Physoderma* Brown Spot from Tar Spot

- *Physoderma* brown spot forms purple-to-brown circular spots along the leaf midrib and small, light-brown to orange circular spots in the leaf tissue.
- Tar spots are raised while *Physoderma* spots are not. *Physoderma* brown spot symptoms are often observed near the leaf base while tar spot symptoms occur over the entire leaf blade.

Prevention

Prevention is key since "tar spot can develop quickly and be devastating, as we saw in the wet year of 2018," Chilvers says. "That wet year it even developed fungal structures on some plants' tassels. In one Michigan field, for example, we first identified it on July 8. Two weeks later, affected corn plants senesced prematurely, and by September 7, those plants were done. Besides yield reduction, there is heavy lodging potential as well."

Albert Tenuta, a field crop plant pathologist with Ontario Ministry of Agriculture, Food and Rural Affairs, agrees: "I've been a crop pathologist for 30 years and was quite surprised at how rapidly it spread along Lake Erie's north shore and became widespread throughout southwestern Ontario."

Resistant hybrids are our best prevention tool, according to Telenko. "No hybrids are fully resistant to tar spot. In 2018, when the disease first hit us, we evaluated hybrids in Illinois, Indiana, Michigan, and Wisconsin: Fields with a 40–50% tar spot severity on the ear leaf by R5/R6 saw a 17–39 bu/ac yield loss.

"Looking at yield loss by maturity grouping, we saw about a 0.3–1.4 bu/ac loss per 1% increase in tar spot," Telenko adds "Early maturing hybrids had 0.5 bu/ac yield loss per 1% increase in tar spot severity on the ear leaf. Late-maturing hybrids had 0.8 bu/ac

yield loss per 1% increase in tar spot severity on the ear leaf."



The left-hand photo is untreated tar-spot-infested corn. Corn in the right-hand photo was sprayed with fungicide following Tarspotter app guidelines. Photo courtesy of Damon Smith, University of Wisconsin.

Less susceptible hybrids tended to have 15% or less leaf area covered with tar spot stroma and less yield loss, according to 2018 Crop Protection Network research. Highly susceptible hybrids had a range of 40–50% stroma-covered leaf area. This is likely because tar spot is a late-season disease, and late-maturing hybrids have more green plant host material available to be infected.It takes five to eight years for new hybrids to come through breeding pipelines, Chilvers says. "Hopefully there are considerable efforts to screen for tar-spot resistance."

Besides genetic resistance, other prevention tools are reducing unnecessary irrigation and leaf wetness, early detection, scouting, residue management, and crop rotation.

An effective technologic prevention tool is the Tarspotter smartphone app. It calculates a field's daily risk of developing tar spot based on local weather. Weather is accessed based on GPS coordinates. The tool was developed using research form past tar spot epidemics and models developed by University of Wisconsin–Madison field crop pathologist Damon Smith, (see **https://ipcm.wisc.edu/apps/tarspotter/**). Its models also drive many fungicide-related economic decisions. The iPhone and Android apps are periodically updated to incorporate new research.

Use it along with scouting to confirm whether the disease is active and whether your crop might be risk of yield loss. If risk factors are met and corn is still accumulating dry

matter, then fungicide application could be warranted, even if one was already applied at the VT–R1 growth stage. Typically, fungicide application isn't recommended past growth stage R4, Chilvers says.

What We Know about Managing Tar Spot

Tar spot management expertise is still developing due to its new arrival in the U.S. and Canada. American university Extension pathologists have made enormous strides, though, in making these recommendations. Timing is everything in successfully managing tar spot, says Wisconsin's Smith. The Crop Protection Network makes these suggestions:

Avoid Highly Susceptible Hybrids

Avoid highly susceptible hybrids where local trials have revealed tar spot badly cutting yields. All hybrids have some susceptibility, but identify which ones that are relatively less susceptible.

Apply the Right Fungicides at the Right Time

Several fungicides with "2ee" labels can potentially manage tar spot. (See the related "Fungicide Efficacy for Control" chart included in this article from the Crop Protection Network.) In 2021 trials of the Crop Protection Network Tar Spot Working Group, two fungicide applications (one at the start of the epidemic at V10 and another at R2) were needed to hold off tar spot. The Tarspotter app can help to make these complicated spray decisions and optimize fungicide performance.

The best fungicide return on investment (ROI) is to apply fungicide only once at VT–R1, according to an article by the Crop Protection Network (**https://bit.ly/3r6AjI8**). The article states that fungicides are only effective in managing tar spot for about two to three weeks after application.

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Fungicide mode of action groups:
Group 11 QoI Strobilurins
Group 3 DMI Triazoles
Group 7 SDHI

Efficacy categories:
NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good;
E=Excellent; NL = Not Labeled for use against this disease;
U = Unknown efficacy or insufficient data to rank product

Fungicide Efficacy for Control of Corn Diseases Table (03/2021)

	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)	Anthracnose leaf blight	Common rust	Eyespot	Gray leaf spot	Northern corn leaf blight	Southern rust	Tar spot[1]	Harvest restriction[2]
11	Azoxystrobin 22.9%	Quadris 2.08 SC, multiple generics	6.0 - 15.5	VG	E	VG	E	G	VG	NL	7 days
11	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 - 12.0	VG	E	E	E	VG	VG	NL	7 days
11	Picoxystrobin	Aproach 2.08 SC	3.0 – 12.0	VG	VG-E	VG	F-VG	VG	G	G[3]	7 days
3	Flutriafol 20.9%	Xyway LFR 1.92 SC Xyway 3D 2.5 SC	LFR: 7.6-15.2 3D: 5.8-11.8	NL	U	NL	VG-E	VG	NL	NL	N/A
3	Propiconazole 41.8%	Tilt 3.6 EC, multiple generics	2.0 - 4.0	NL	VG	E	G	G	F	NL	30 days
3	Prothioconazole 41.0%	Proline 480 SC	5.7	U	VG	E	U	VG	G	NL	14 days
3	Tebuconazole 38.7%	Folicur 3.6 F, multiple generics	4.0 - 6.0	NL	U	NL	U	VG	F	NL	36 days
3	Tetraconazole 20.5%	Domark 230 ME	4.0 – 6.0	U	U	U	E	VG	G	G-VG[3]	R3 (milk)
11 3	Azoxystrobin 13.5% Propiconazole 11.7%	Quilt Xcel 2.2 SE, multiple generics	10.5 - 14.0	VG	VG-E	VG-E	E	VG	VG	G-VG[3]	30 days
7 11 3	Benzovindiflupyr 2.9% Azoxystrobin 10.5% Propiconazole 11.9%	Trivapro 2.21 SE	13.7	U	U	U	E	VG	E	G-VG	30 days
3 11	Cyproconazole 7.17% Picoxystrobin 17.94%	Aproach Prima 2.34 SC	3.4 – 6.8	U	U	U	E	VG	G	G-VG[3]	30 days
3 11	Flutriafol 19.3% Fluoxastrobin 14.84%	Fortix 3.22 SC Preemptor 3.22 SC	4.0 -6.0	U	U	U	E	VG	VG	G-VG[3]	R4 (dough)
3 7	Flutriafol 26.47% Bixafen 15.55%	Lucento	3.0-5.5	U	U	U	VG-E	VG	VG	G[3]	R4
3 11	Flutriafol 18.63% Azoxystrobin 25.30%	TopGuard EQ	5.0-7.0	U	F	U	VG	G	G	G-VG[3]	7 days
3 11	Mefentrifluconazole 17.56a5 Pyraclostrobin 17.56%	Veltyma	7.0-10.0	U	U	U	VG-E	VG-E	VG	G-VG	21 days
3 11 7	Mefentrifluconazole 11.61% Pyraclostrobin 15.49% Fluxapyroxad 7.74%	Revytek	8.0-15.0	U	U	U	VG-E	VG-E	VG	G-VG	21 days
3 11	Prothioconazole 16.0% Trifloxystrobin 13.7%	Delaro325 SC	8.0-12.0	VG	E	VG	E	VG	G-VG	G-VG	14 days
3 7 11	Prothioconazole 14.9% Trifloxystrobin 13.1% Fluopyram 10.9%	Delaro Complete[4] 3.83 SC	8.0-12.0	U	U	U	E	U	VG	G-VG	35 days
7 11 3	Pydiflumetofen 7.0% Azoxystrobin 9.3% Propiconazole 11.6%	Miravis Neo 2.5 SE	13.7	U	U	U	E	VG-E	VG	G-VG	30 days
11 7	Pyraclostrobin 28.58% Fluxapyroxad 14.33%	Priaxor 4.17 SC	4.0 – 8.0	U	VG	U	VG	VG-E	VG	G-VG[3]	21 days
11 3	Pyraclostrobin 13.6% Metconazole 5.1%	Headline AMP 1.68 SC	10.0 - 14.4	U	E	E	E	VG	G	G-VG	20 days
11 3	Trifloxystrobin 32.3% Prothioconazole 10.8%	Stratego YLD 4.18 SC	4.0 - 5.0	VG	E	VG	E	VG	G	NL	14 days
3 11	Tetraconazole 7.48% Azoxystrobin 9.35%	Affiance 1.5 SC	10.0-14.0	U	G-VG	U	G-VG	G-VG	G	G[3]	7 days

Indicates product with mixed fungicide classes

[1]Fungicide application timing is extremely important and needs to be made near the onset of the tar spot symptoms. Efficacy ratings based on limited site locations from 2018 to 2020. [2]Harvest restrictions are listed for field corn harvested for grain. Restrictions may vary for other types of corn (sweet, seed or popcorn, etc.), and corn for other uses such as forage or fodder. [3]A 2ee label is available for several fungicides for control of tar spot, however efficacy data are limited. Check 2ee labels carefully, as not all products have 2ee labels in all states. [4]Delaro Complete is not labeled for use on corn in all states as of January 2021. This information is provided only as a guide. It is the applicator's legal responsibility to read and follow all current label directions. Reference in this publication to any specific commercial product is for general information only, and does not constitute an endorsement or recommendation by the CDWG. Individuals using such products assume responsibility for their use in accordance with current directions of the manufacturer. Members or participants in the CDWG assume no liability resulting from the use of these products.

The second to the far-right column lists fungicides tested on tar spot. Veltyma, Delaro Complete, and Miravis Neo are the three most commonly used fungicides used to control

tar spot. Applying fungicide between V8 (late-emerge leaves) and R4 (late reproductive stage) are when the return on investment (ROI) is highest. The Tarspotter app is useful in determining when ROI is highest. Fungicide timing is extremely important with application needed near the onset of tar spot symptoms. Source: The Crop Protection Network (***https://bit.ly/3H8l6Wc****).*

"At R5, kernel dry matter accumulation is approximately 45% of total dry weight, leaving half to be accumulated during this developmental stage. At [corn's] half milk line, approximately 90% of total dry matter exists. Stresses during this period result in a reduction in kernel weight. The degree of yield protection will depend on the level of disease currently in the crop, susceptibility of that hybrid to tar spot (and other diseases), and upcoming weather conditions.

"For example, in Michigan, an industry colleague applied a second fungicide application on August 20, 2019, and saw a 20 bu/ac benefit over a single fungicide application at silking. Tar spot was detected in mid-August in that field and continued to develop with overhead irrigation. However, when those trials were repeated in 2020, there was no yield response from the second fungicide application, even in the presence of disease.



Scouting can be an important tool for preventing tar spot, particularly when paired with the Tarspotter smartphone app, which calculates a field's daily risk of developing tar spot based on local weather. Photo by Beth Wood.

"Always leave non-fungicide-treated check strips to determine the ROI and learn from the process."

Reduce Irrigation Frequency and Leaf-Wetness Duration

Anecdotal evidence indicates that excessive irrigation or frequent, light irrigation events may increase disease. For example, one irrigated field where Headline AMP was applied at silking (R1) still developed tar spot in 2019.

Scout and Monitor for Tar Spot Reports in Your Area

Scout for tar spot and be prepared to apply fungicides or harvest heavily diseased fields early to avoid lodging. In-season confirmations of tar spot across the U.S. can be monitored at **https://corn.ipmpipe.org/tarspot/**.

Look for Lodging Potential

As tar spot develops in a field, look for lodging potential. "It may even be necessary to pay a little more for drying to get some fields in before they lodge," Chilvers says.

Rotate to Other Crops

Much remains to be learned about crop rotation's minor role in reducing risk, but it makes sense to allow residue to decompose and reduce inoculum while fields support other crops. "I've seen plenty of incidences of rotated fields getting hit with tar spot," Tenuta says. "Its spores can travel many miles and overcome having done all the right things."

Researchers don't yet know the requisite number of years rotated away from corn that will reduce inoculum, says Dean Malvick, University of Minnesota Extension plant pathologist.

Manage Residue

Tillage appears to play a minor role in reducing tar spot risk. Burying infected residue and accelerated decomposition may help reduce the amount of inoculum. However, this doesn't reduce infection risk from new, locally dispersed inoculum.

Fungicide Considerations

In deciding whether to spray a fungicide, Purdue's Telenko recommends these four considerations beforehand:

1. Disease risk in a field—is there a previous history of the disease?
2. Current disease activity—do you find the disease in the lower canopy while scouting?
3. Weather conditions—will there continue to be favorable weather moisture and rain for foliar diseases?
4. Return on investment—will the yield protected by a fungicide cover the additional cost of the application?

"We recommend holding off until the disease becomes active in your field and corn is at least at V8, nearing VT/R1 (tassel/silk), or even R2 (blister) if drier conditions develop," Telenko says.

Uniform tar spot efficacy trials in 2019–2020 trials in Illinois, Indiana, Michigan, and Wisconsin found that all fungicides reduced tar spot. Those labeled with an "e" are the top performers. Veltyma, Delaro, and Revytek consistently increased yield over nontreated checks during 2019 and 2020, Telenko says (see Figure 1).

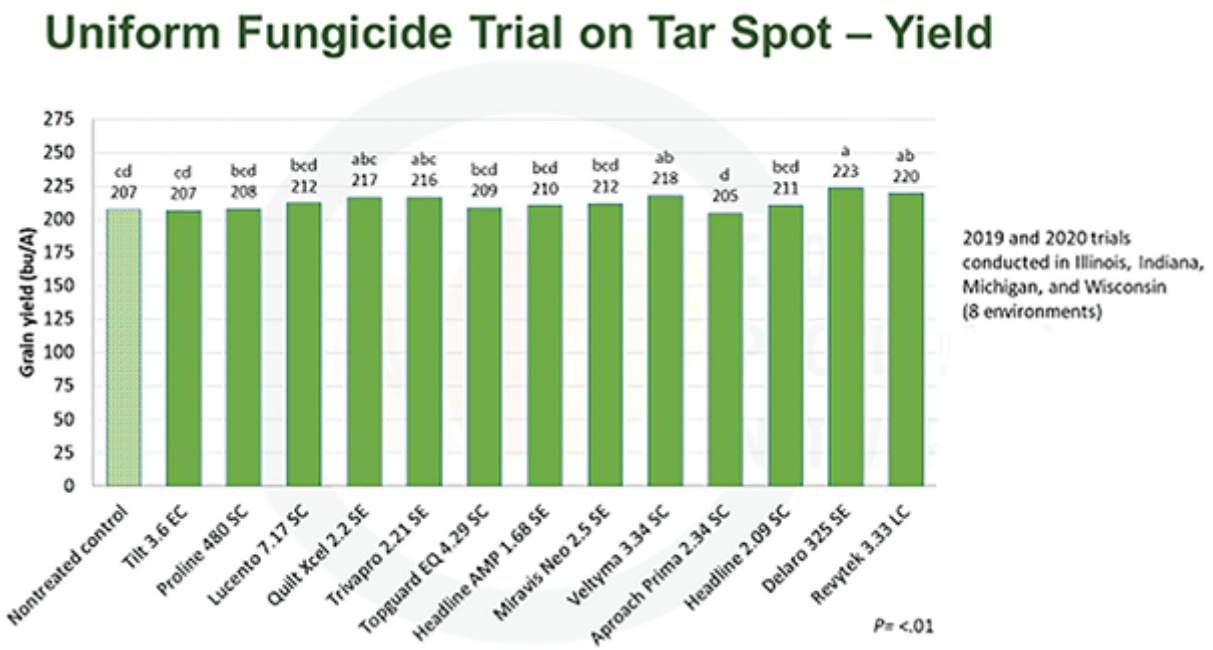


Figure 1, *Averaged across all tar spot fungicide trials in 2019 and 2020 in Illinois, Indiana, Michigan, and Wisconsin, yield significantly increased by Delaro, Revytek, and Veltyma over the nontreated control. Values are least square means. Values with different letters are significantly different based on least square means test (? = 0.05). Source: Telenko et al. (2022). Fungicide efficacy on tar spot and yield of corn in the Midwestern United States. Plant Health Progress.* ***https://doi.org/10.1094/PHP-10-21-0125-RS****.*

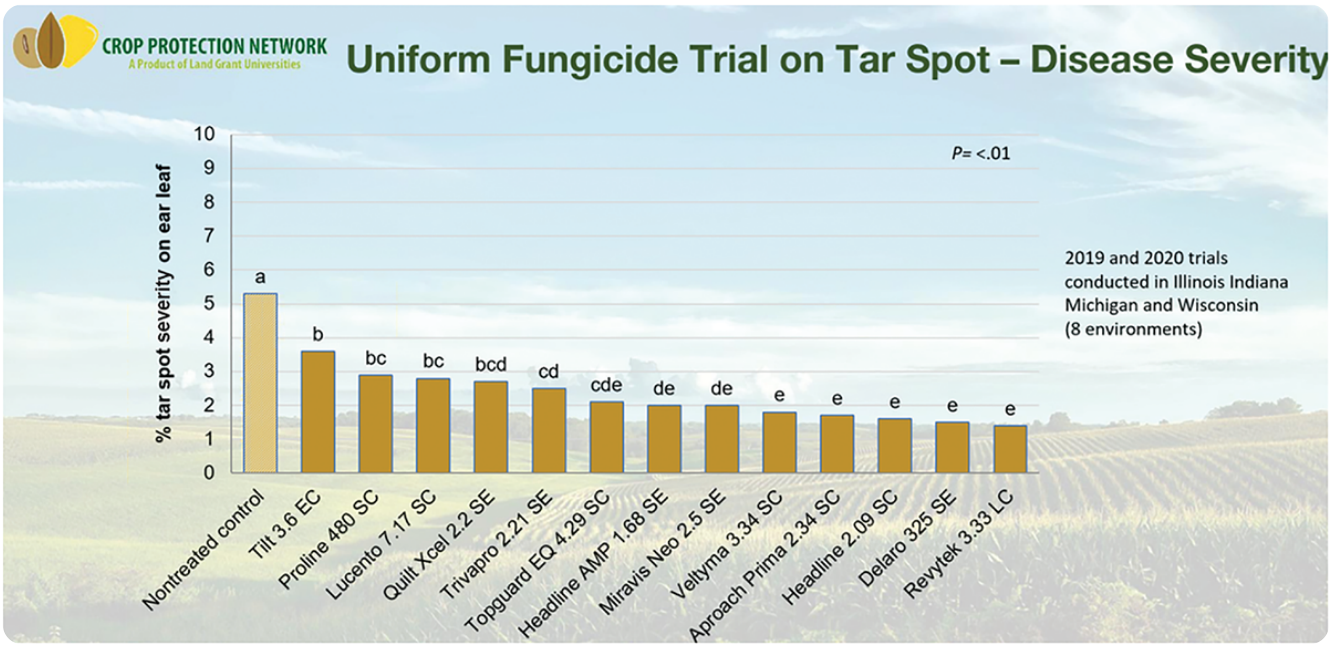


Figure 2, *Across all fungicide trials in 2019 and 2020 in Illinois, Indiana, Michigan, and Wisconsin, the nontreated plots had 5% of the ear leaf consumed by tar spot at R5 compared with 1 to 2% of the ear leaf diseased by the most effective fungicides with a letter "e." Tar spot severity was rated visually by assessing the percentage of the symptomatic leaf area on the ear leaf on five plants per plot at the dent growth stage (R5). Values are least squares means. Values with different letters are significantly different based on least square means test (? = 0.05). Source: Telenko et al. (2021). Fungicide efficacy on tar spot and yield of corn in the Midwestern United States. Plant Health Progress.* ***https://doi.org/10.1094/PHP-10-21-0125-RS****.*

"Across all trials, the nontreated plants had 5% of the ear leaf consumed by tar spot at R5 compared with 1–2% of the ear leaf diseased by the most effective fungicides," Telenko says (Figure **2**). "[Fungicides] with two modes of action and three modes of action outperformed the nontreated checks. The products with three modes of action were the only ones that significantly outyielded the nontreated plots."

A 2019 Indiana tar spot fungicide trial found a change in corn yield of 3.5 bu/ac to 21 bu/ac in fungicide-treated corn compared with nontreated corn.

Additional Tar Spot Resources

- For current tar spot updates: **https://corn.ipmpipe.org/tarspot/**
- Crop Protection Network's *Tar Spot of Corn: Web Book*: **https://bit.ly/3u6BLWO**
- New and Emerging Diseases in Field Crops: Tar Spot Of Corn: **https://bit.ly/3G6kjEa**.
- **#tarspot** on Twitter
- *Pest & Crop* newsletter from Purdue University: **https://bit.ly/Purdue_tarspot**.
- Michigan State University Extension Corn Newsletter: **www.canr.msu.edu/corn/index**.

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