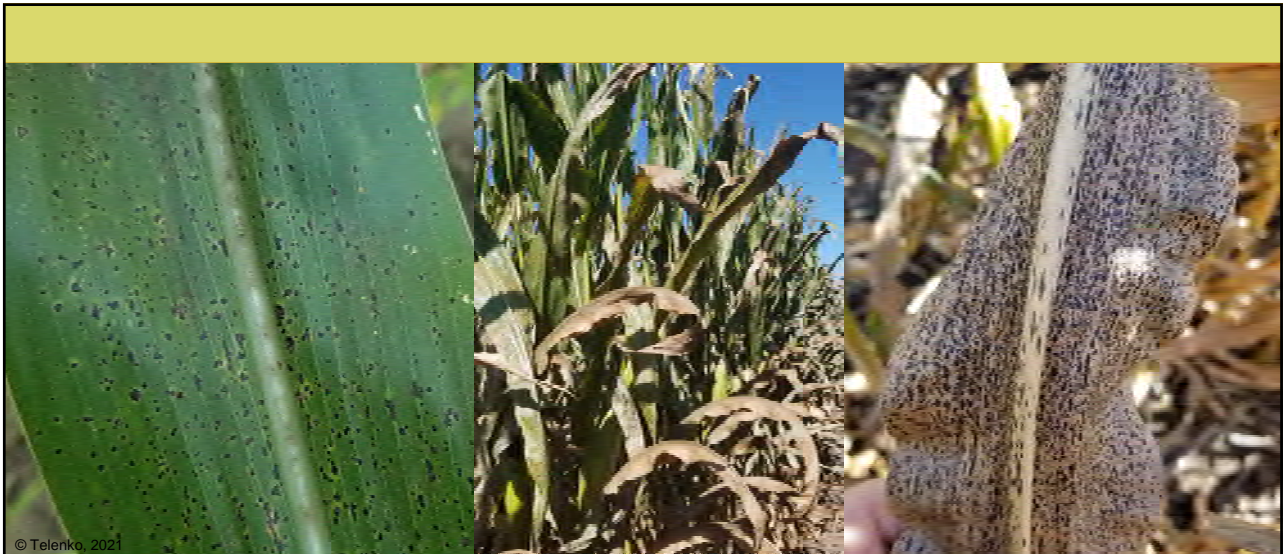




DISEASE UPDATE

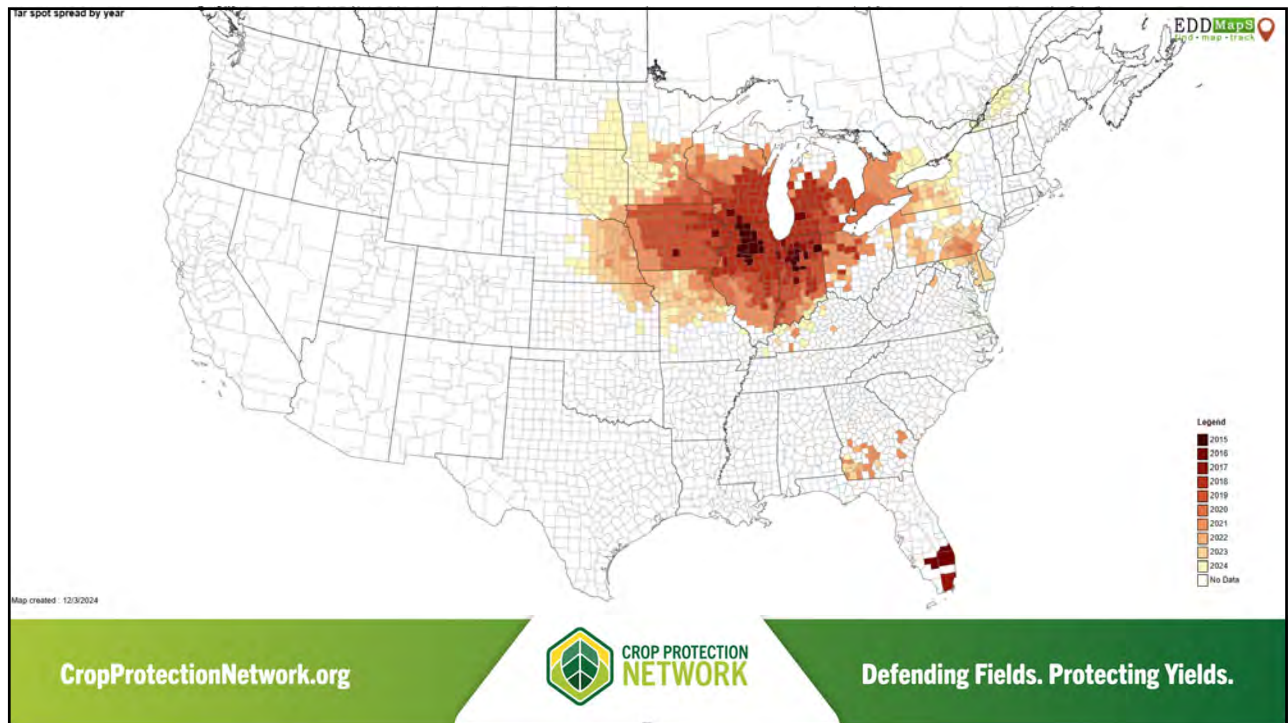
Darcy Telenko, Ph.D.
Associate Professor and Field Crop Extension Pathologist



© Telenko, 2021



Tar spot of corn



My 10 Points after Seven Seasons of Tar Spot

1. Every year has been different – disease triangle!
2. Scouting is critical
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4. Fungicides will work, but tar spot shows limitations
5. Timing is critical – can be too early or too late
6. ROI – understand the numbers on 1x vs. 2x applications
7. Corn will never be 100% clean at the end of the season – see #4
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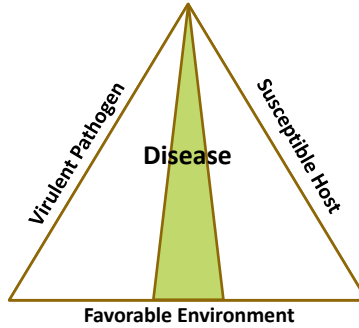
© Telenko 2024



Disease Triangle

Virulent pathogen:

- Overwinter?
- Endemic – already present in soil/debris
- Spore movement



Susceptible host:

- Plant species
- Variety/hybrid susceptibility
- Growth stage

Favorable Environment:

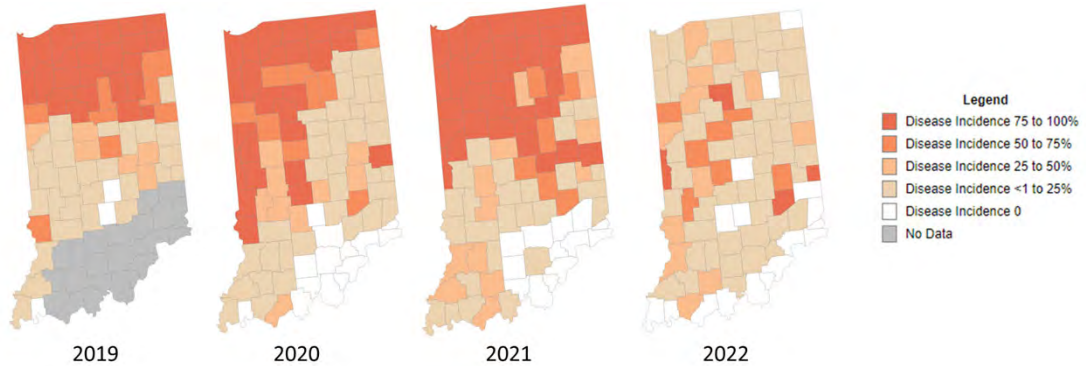
- Temperature
- Moisture
- Leaf wetness

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Survey of Tar Spot Incidence (% of plants)

End of Aug through early September



Source: Waibel, K., Goodnight, K. M., Rocco da Silva, C., Bonkowski, J., Creswell, T., Poudel, P., Quinn, D. J., Ruhl, G., Shim, S., Weaver, J. C., Wise, K. A., and Telenko, D. E. P.1* XXXX. Tracking the distribution and risk of tar spot of corn in Indiana from 2015 to 2022. *Plant Health Progress*. *In press*.

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Examples of tar spot severity on leaves 0.1%, 2.5%, 15%, and 25%



0.1% severity

2.5% severity

15% severity

25% severity

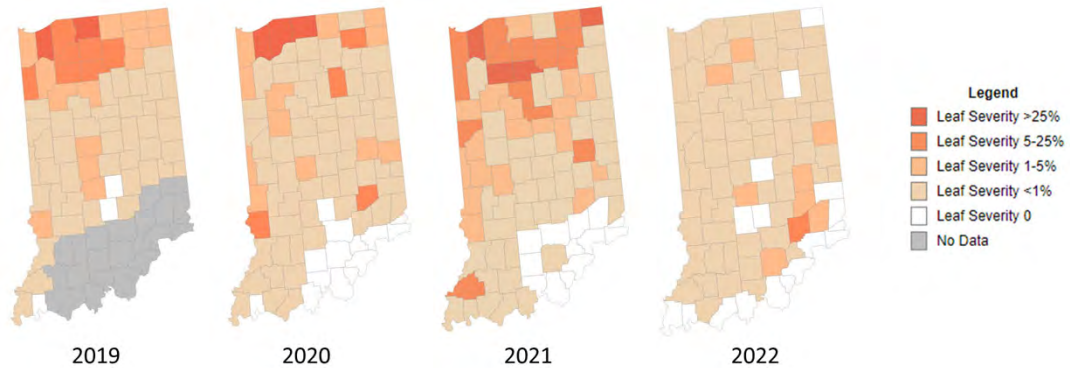
Source: Waibel, K., Goodnight, K. M., Rocco da Silva, C., Bonkowski, J., Creswell, T., Poudel, P., Quinn, D. J., Ruhl, G., Shim, S., Weaver, J. C., Wise, K. A., and Telenko, D. E. P.1* XXXX. Tracking the distribution and risk of tar spot of corn in Indiana from 2015 to 2022. *Plant Health Progress*. *In press*.

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Survey of Tar Spot Leaf Severity (% coverage on leaf)

End of Aug through early September



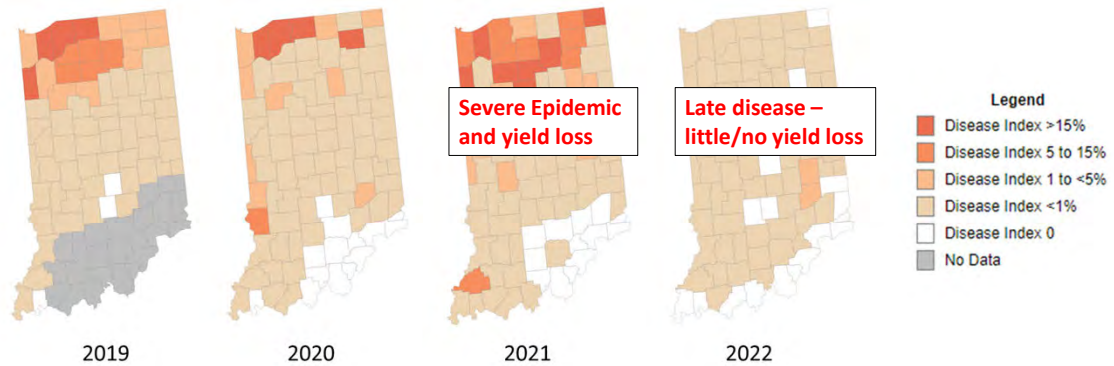
Source: Waibel, K., Goodnight, K. M., Rocco da Silva, C., Bonkowski, J., Creswell, T., Poudel, P., Quinn, D. J., Ruhl, G., Shim, S., Weaver, J. C., Wise, K. A., and Telenko, D. E. P.1* XXXX. Tracking the distribution and risk of tar spot of corn in Indiana from 2015 to 2022. *Plant Health Progress*. *In press*.

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Survey of Tar Spot Index (Incidence x Severity)

End of Aug through early September



Source: Waibel, K., Goodnight, K. M., Rocco da Silva, C., Bonkowski, J., Creswell, T., Poudel, P., Quinn, D. J., Ruhl, G., Shim, S., Weaver, J. C., Wise, K. A., and Telenko, D. E. P.1* XXXX. Tracking the distribution and risk of tar spot of corn in Indiana from 2015 to 2022. *Plant Health Progress*. *In press*.

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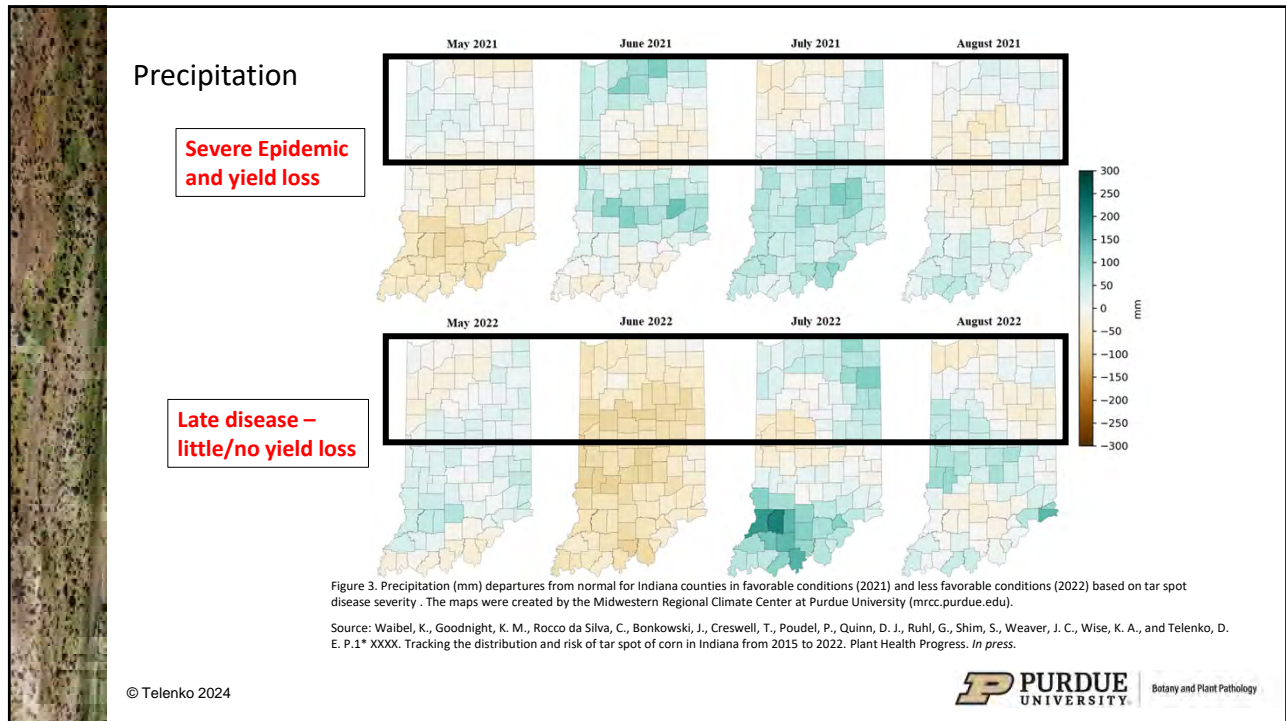
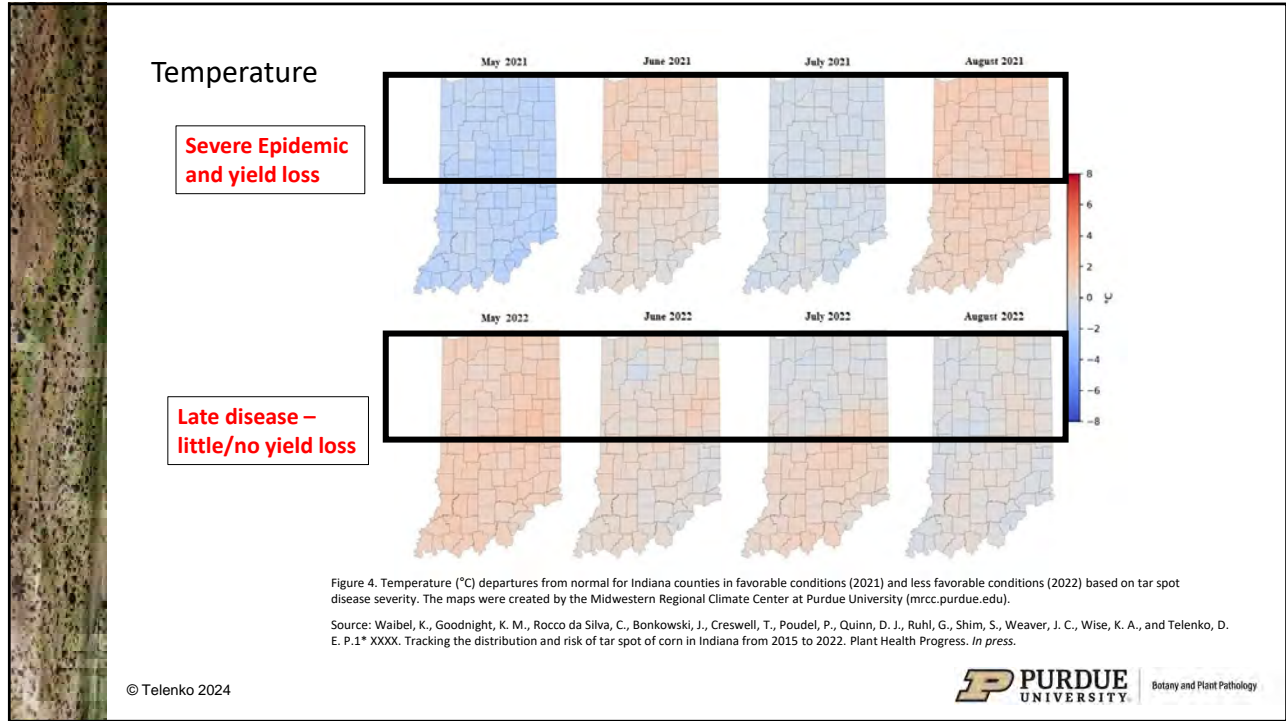
Weather Matters for Tar Spot

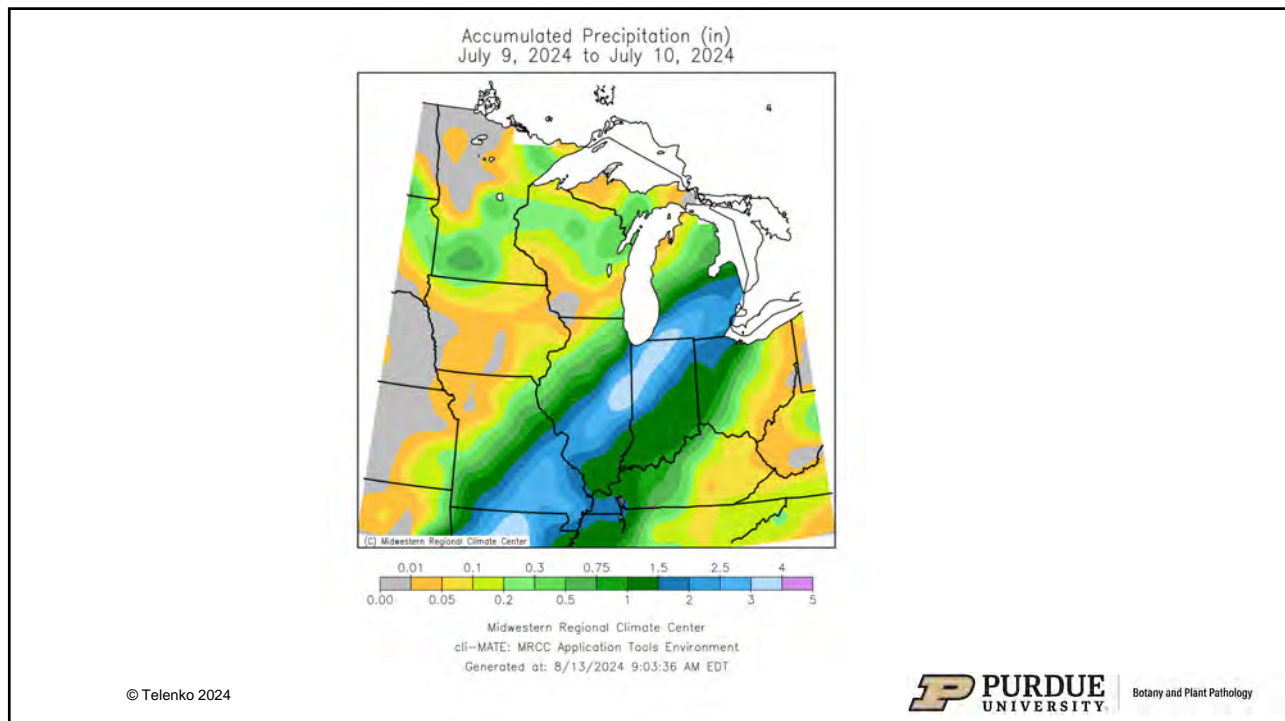
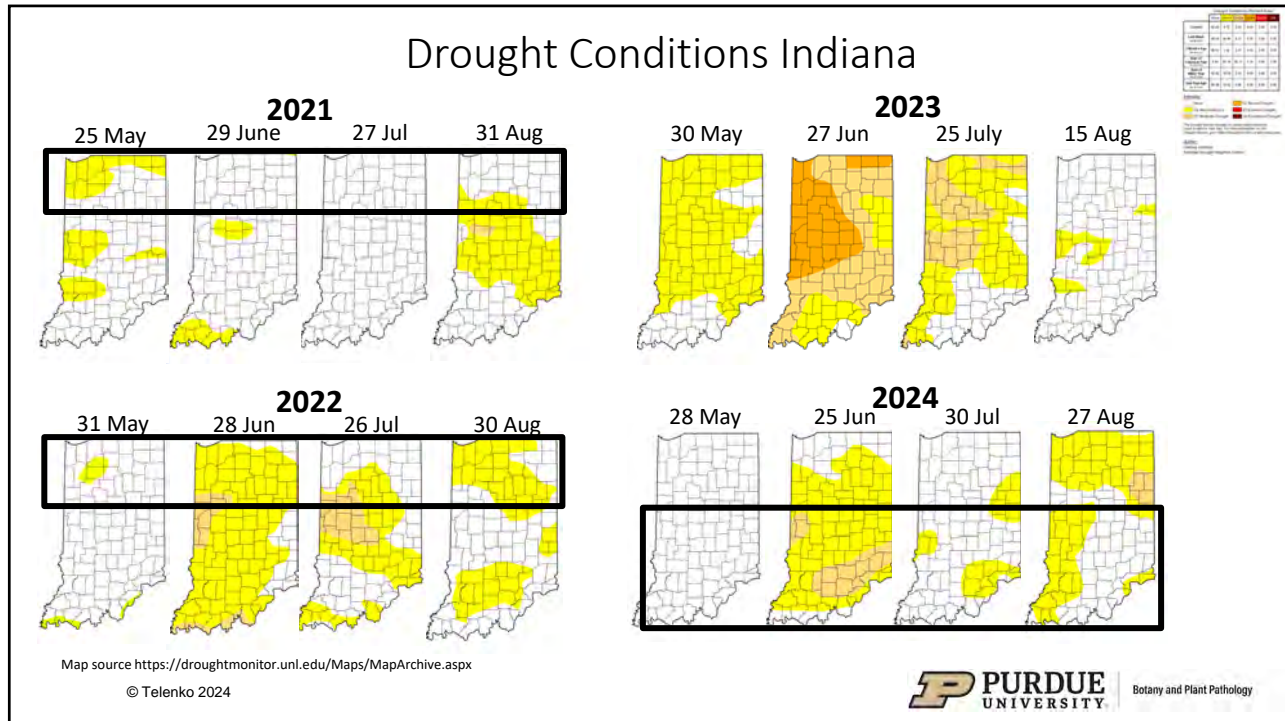
- Temperature is critical:
 - ✓ Optimum conditions when extended periods (30 days) of mild temperature (64-73°F; 18-23°C).
 - ✓ Monthly temperatures that exceed 73°F reduce tar spot progression.
- Moisture plays a role:
 - ✓ Moisture important in process to aid spore germination
 - ✓ Tar spot developed when relative humidity under 90% over 2-3 week span
 - ✓ Extended periods of excessive moisture (RH > 90%), especially at high temperatures, can hinder disease progression.
- Use Prediction Tool: Tarspotter

Source: Webster, R. W., et al. 2023. Tar spot prediction in corn: The weather matters. *Crop Protection Network*. CPN-5012. doi.org/10.31274/cpn-20231220-1

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My 10 Points after Seven Seasons of Tar Spot

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Tar spot 1st reports in Indiana

Based on our trials and PPDL samples

2019 - July 13

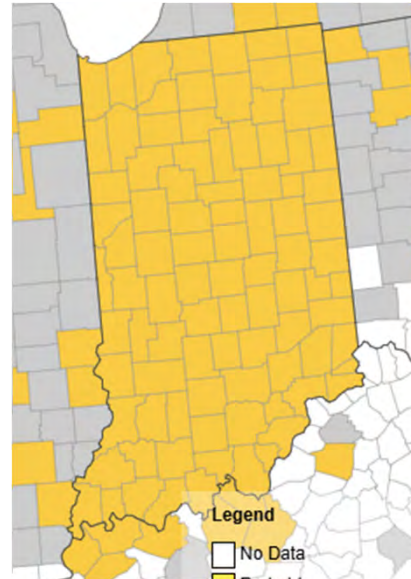
2020 - July 28

2021 - July 3

2022 - July 20/ Sep 1 in our plots

2023 - July 11

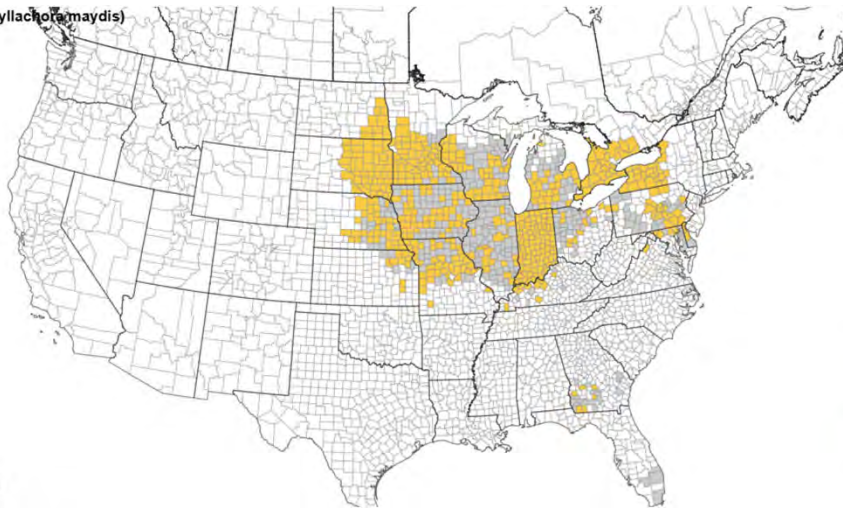
2024 - June 10



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tar spot of corn (*Phyllachora maydis*)



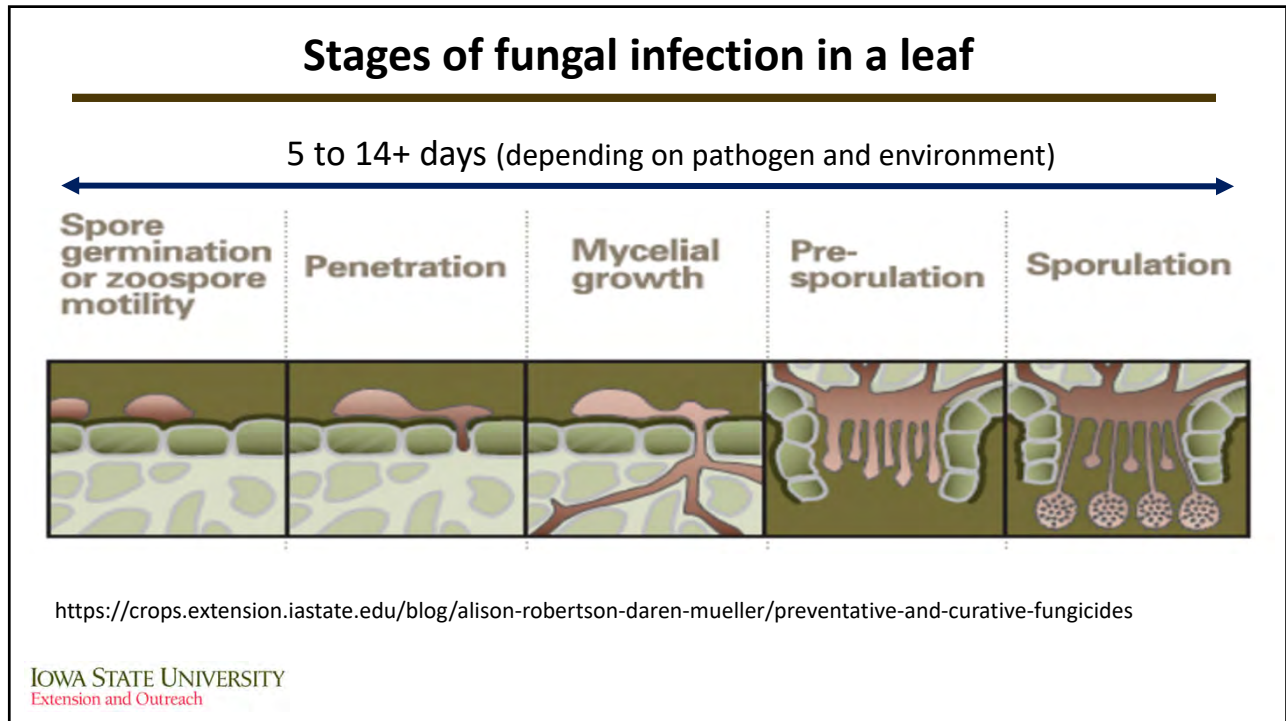
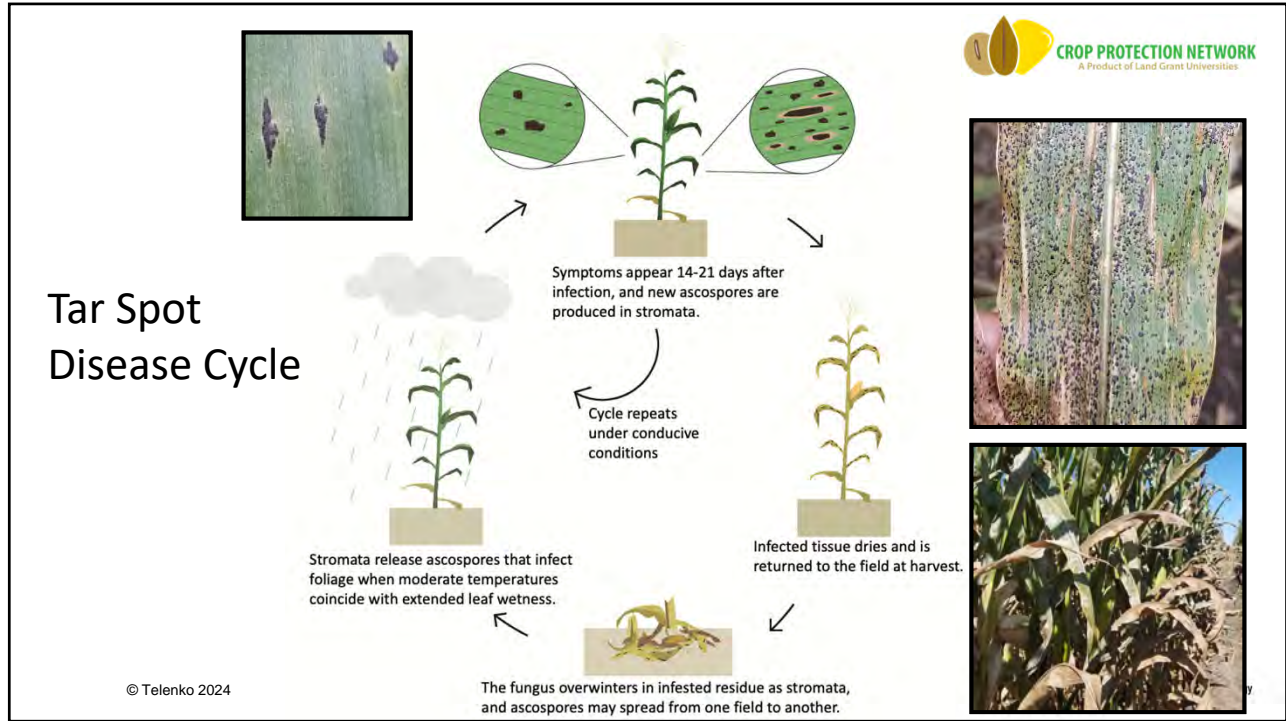
- Legend
- No Data
 - Scouted, but not found
 - Probable
 - Positive
 - Found in previous years

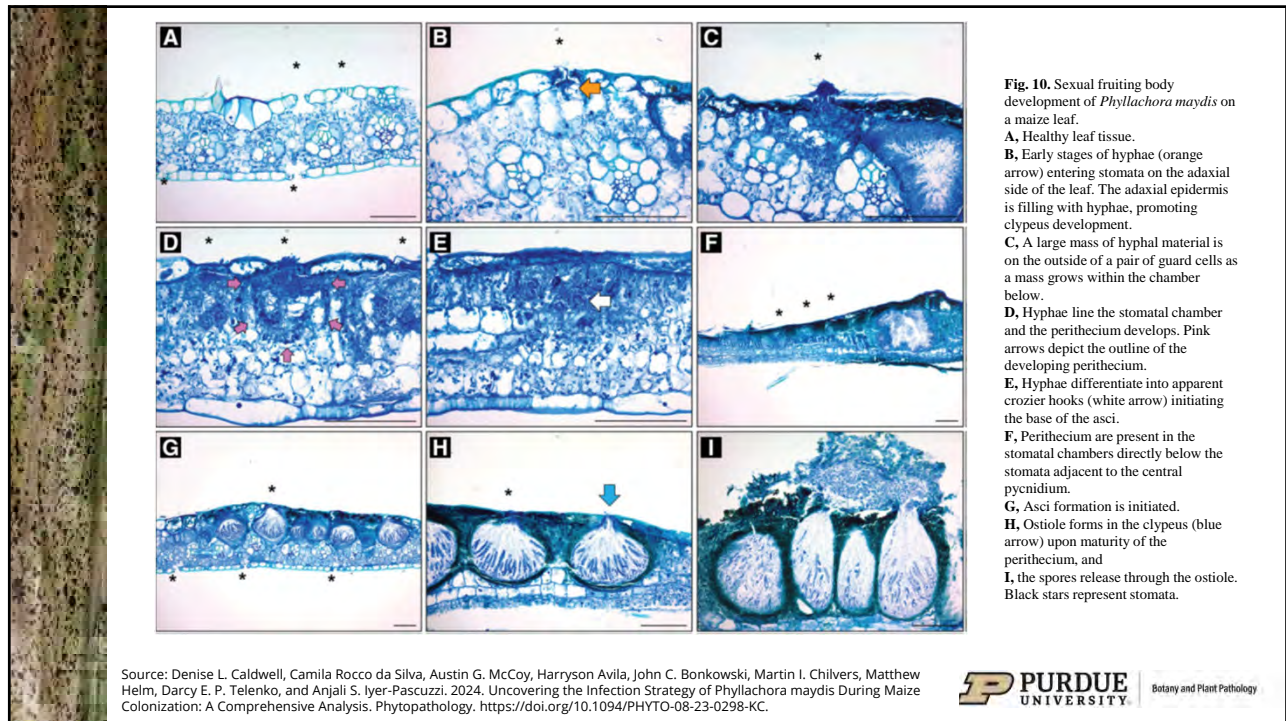
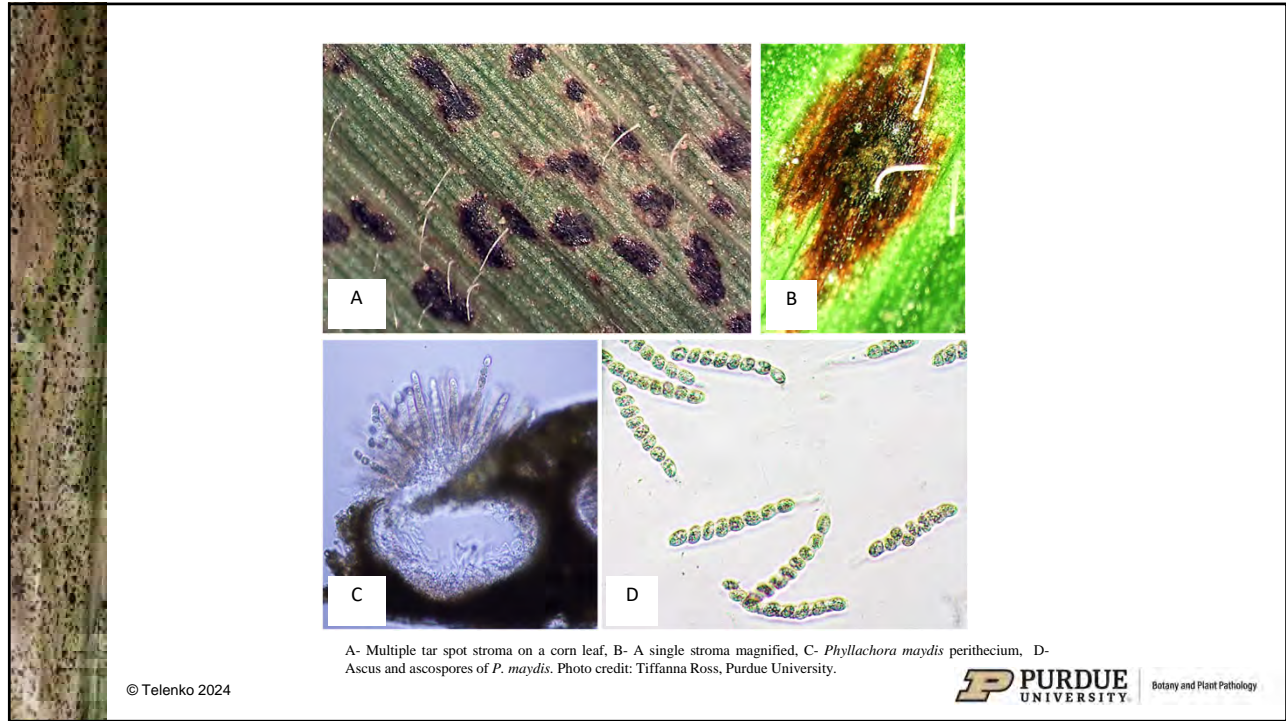
Map created : 10/30/2024

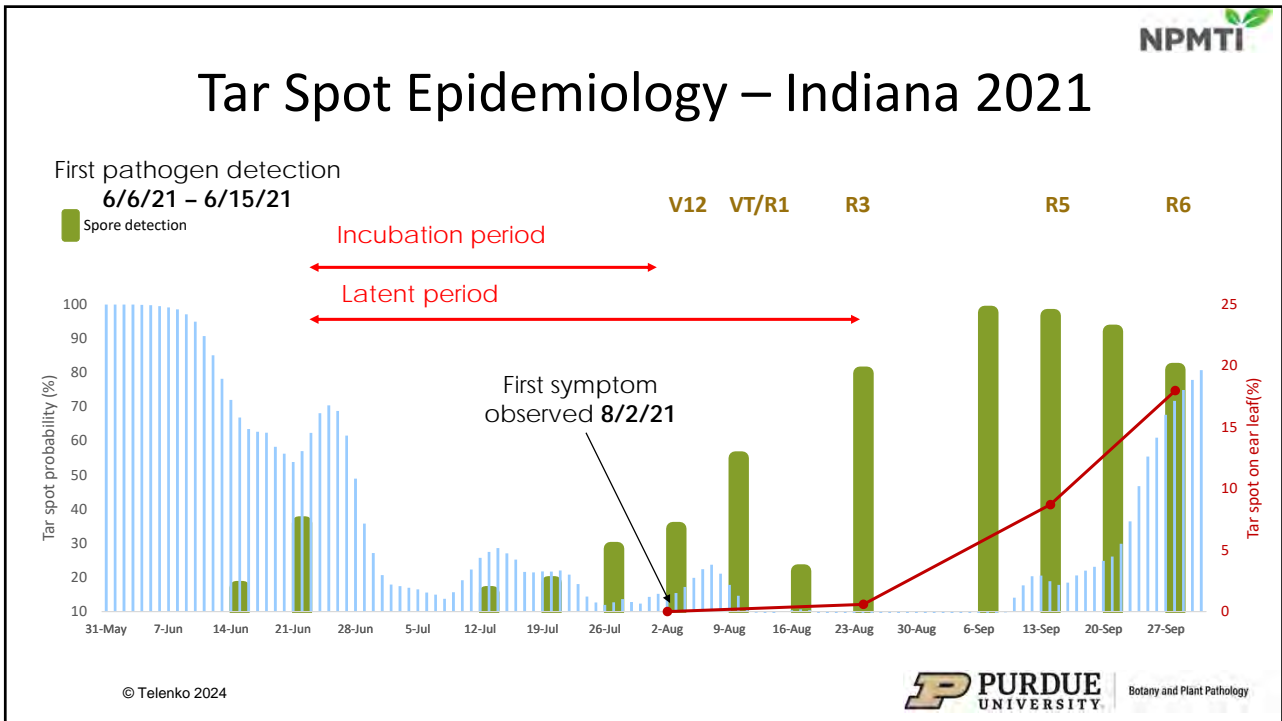
CropProtectionNetwork.org

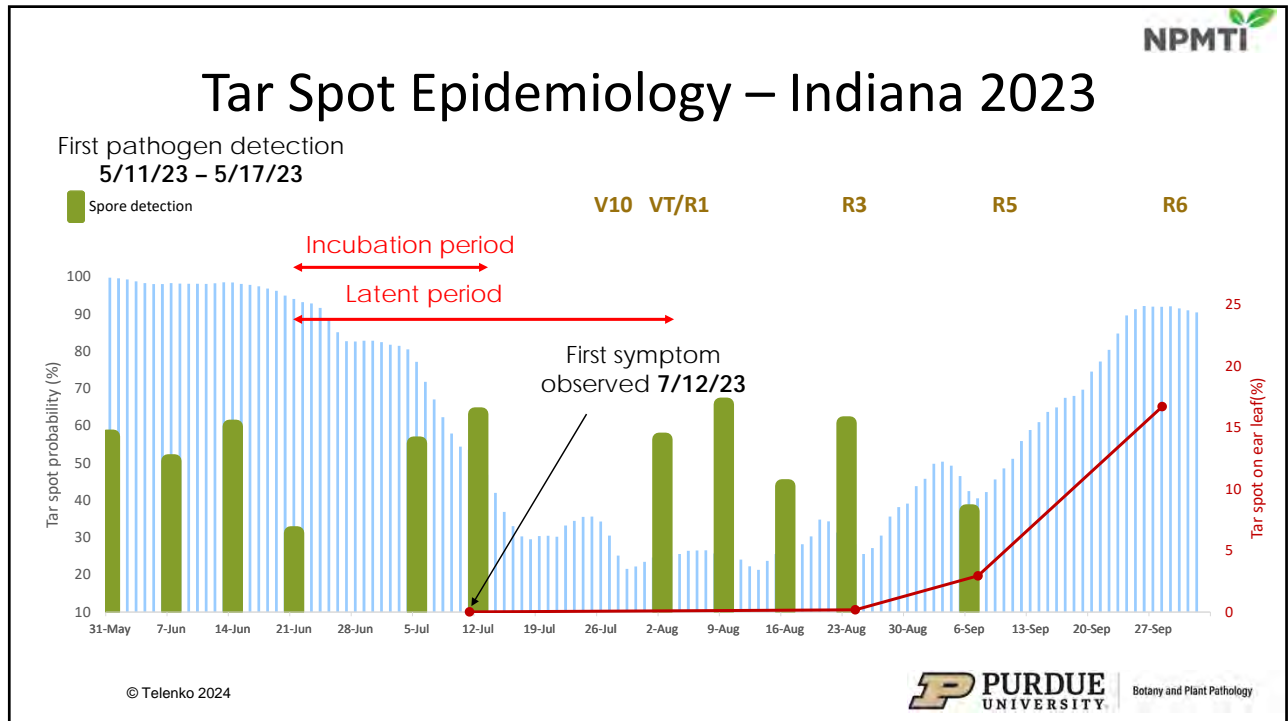
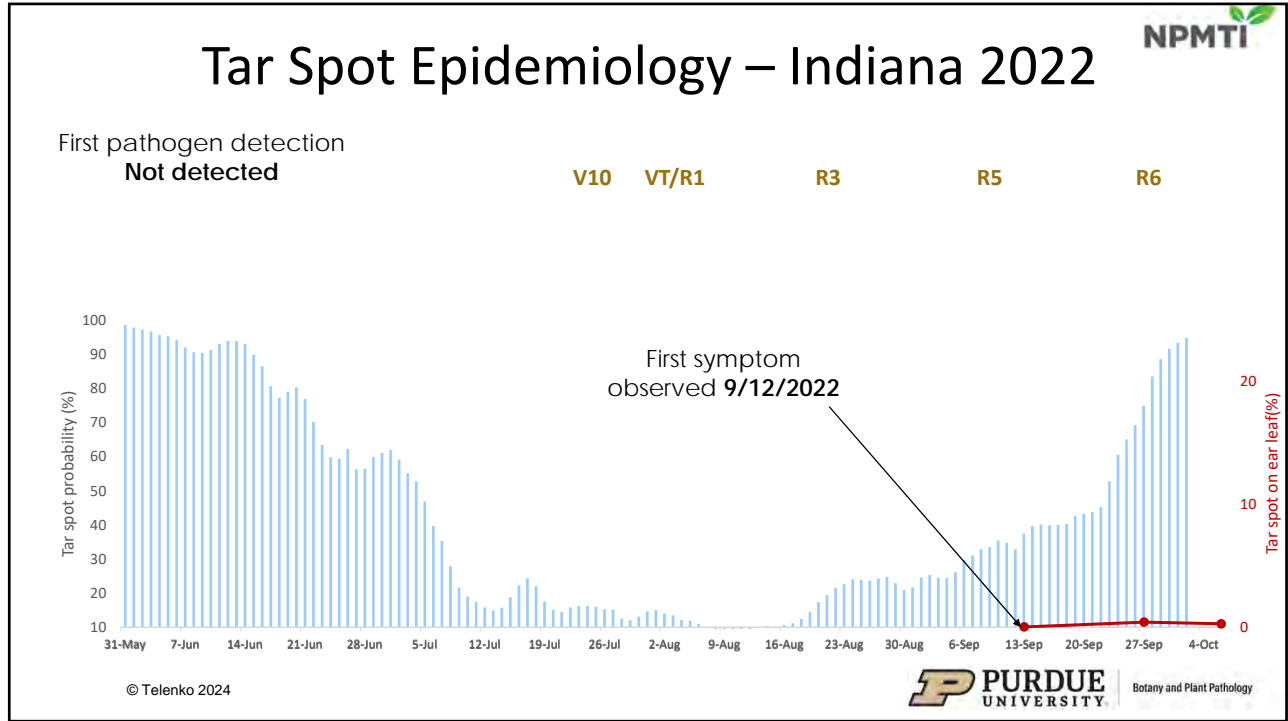


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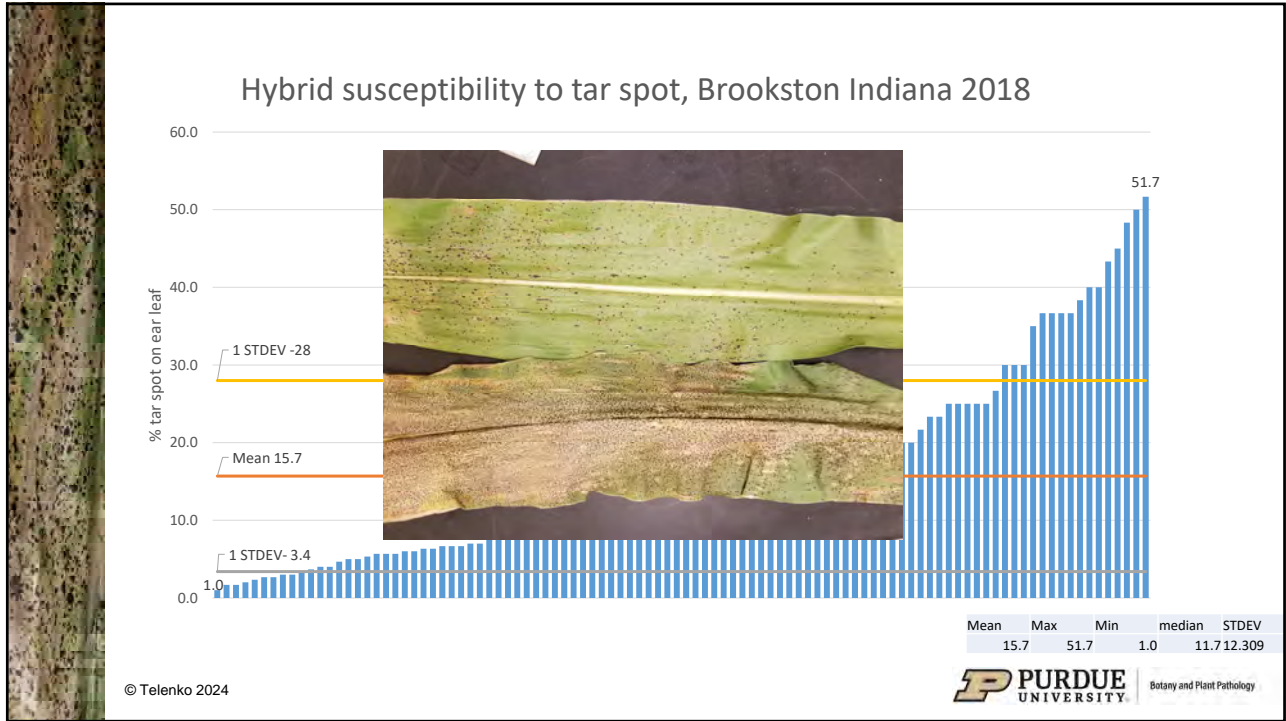
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Variability of Hybrid Susceptibility



© Telenko 2024



Hybrid reaction to tar spot



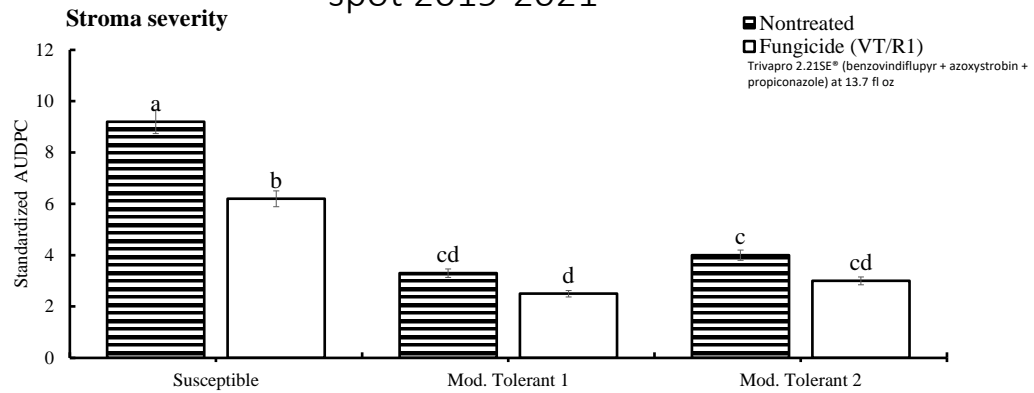
susceptible hybrid

moderately resistant hybrid

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Integration hybrid and fungicide application for control of tar spot 2019-2021

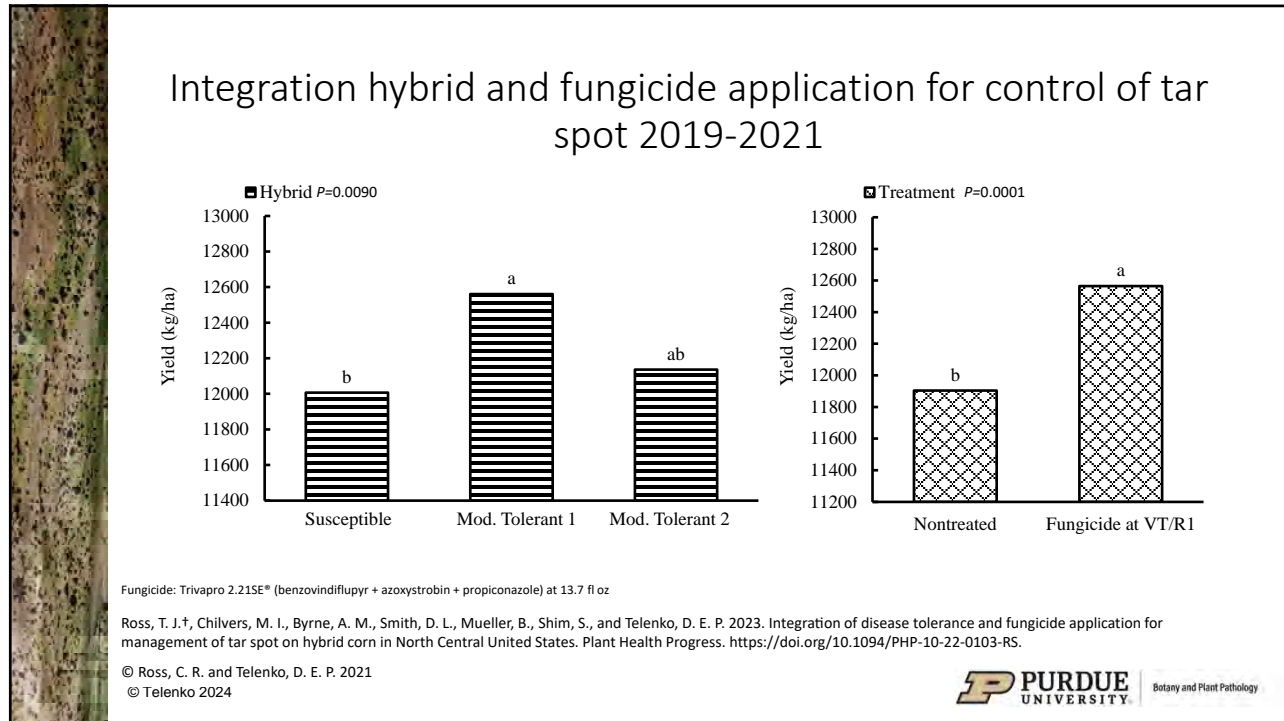


Hybrid x fungicide interaction for stroma severity (AUDPC) ($p=0.0001$) and tar spot symptoms (AUDPC) ($p=0.006$). Values with different letters are significantly different based on least square means test ($\alpha = 0.05$) and indicates pairwise comparisons between nontreated and treated mean within hybrids. AUDPC was standardized by dividing AUDPC by the total length of the disease assessment period.

Ross, T. J.†, Chilvers, M. I., Byrne, A. M., Smith, D. L., Mueller, B., Shim, S., and Telenko, D. E. P. 2023. Integration of disease tolerance and fungicide application for management of tar spot on hybrid corn in North Central United States. *Plant Health Progress*. <https://doi.org/10.1094/PHP-10-22-0103-RS>.

© Ross, C. R. and Telenko, D. E. P. 2021
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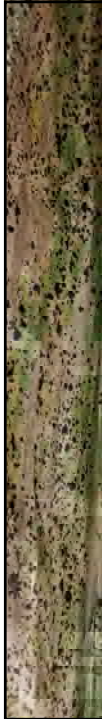


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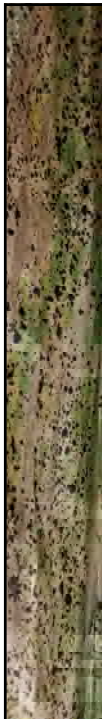
P PURDUE UNIVERSITY Botany and Plant Pathology



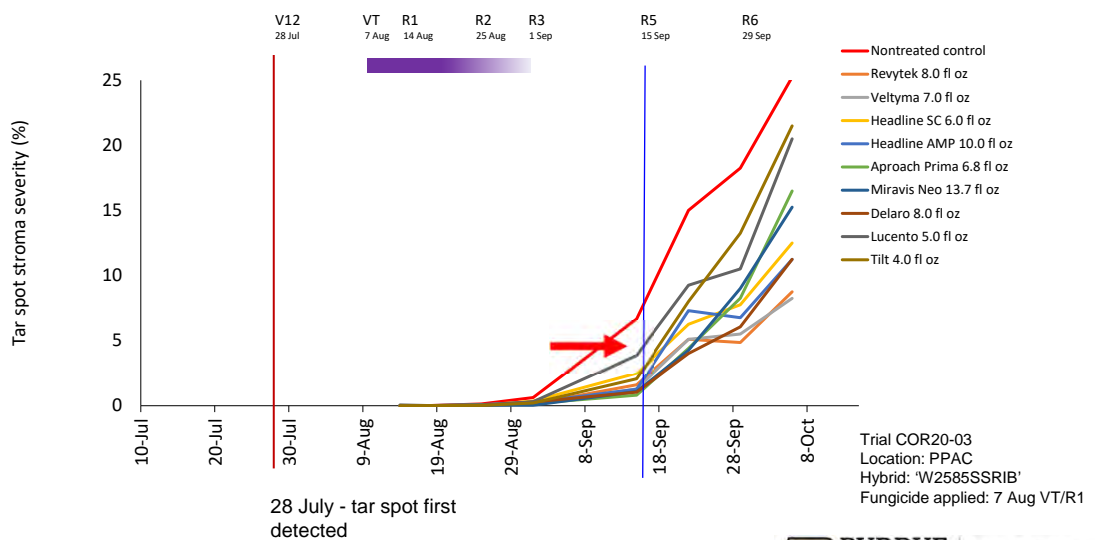
Multi-state Tar Spot Trials

Darcy Telenko, Marty Chilvers, Daren Mueller, Alison Robertson, Damon Smith, Albert Tenuta

© Telenko, 2024

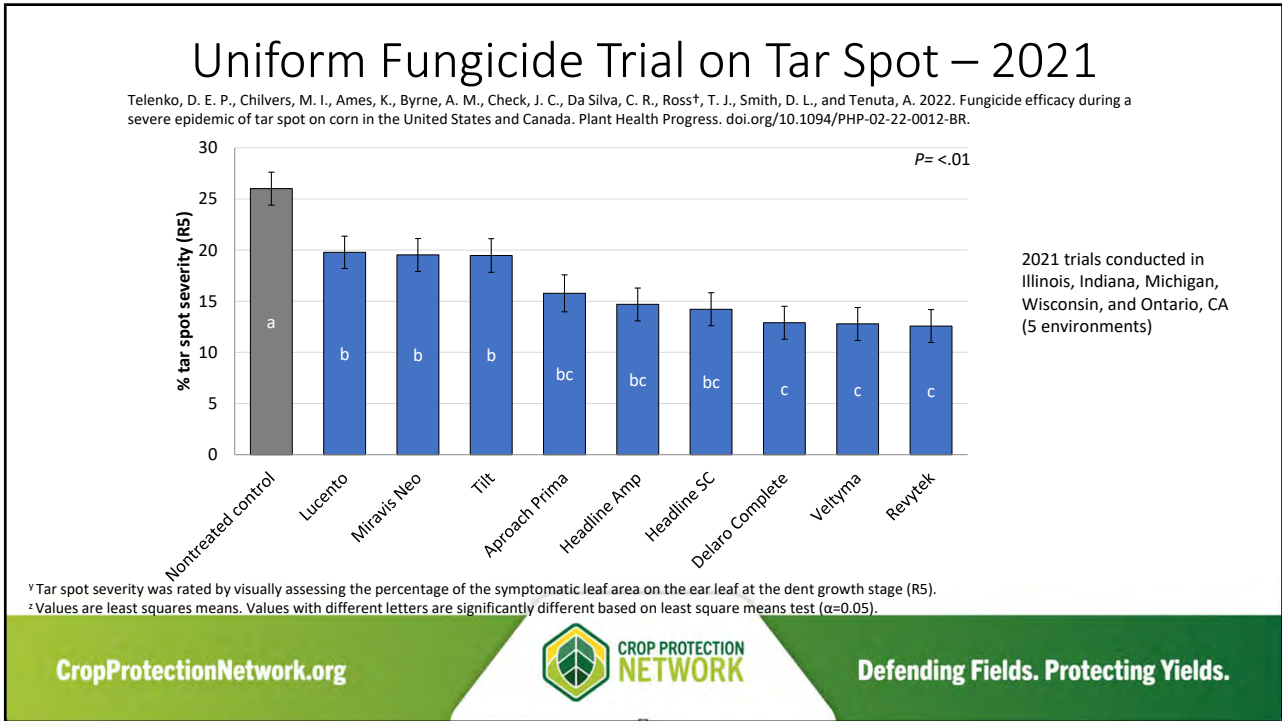
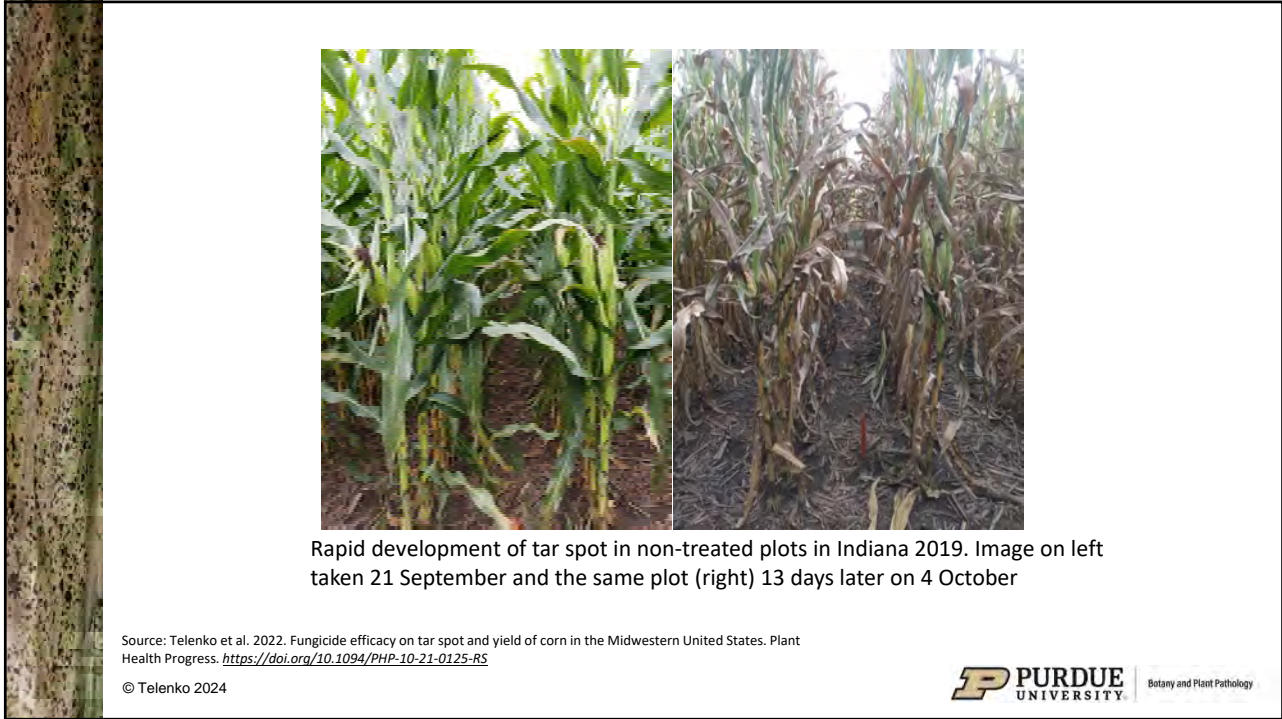


Uniform Fungicide Trial for Tar Spot Disease Progress Indiana 2020



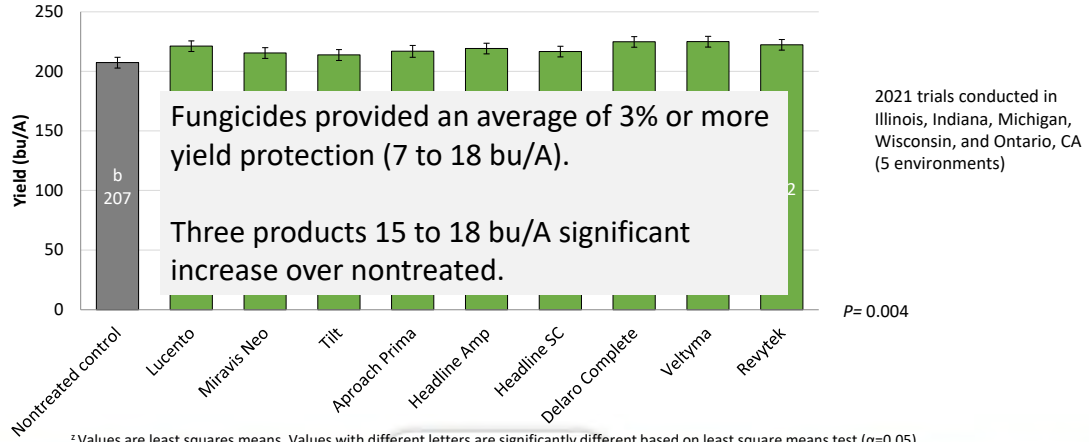
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Uniform Fungicide Trial on Tar Spot – Yield 2021

Telenko, D. E. P., Chilvers, M. I., Ames, K., Byrne, A. M., Check, J. C., Da Silva, C. R., Ross†, T. J., Smith, D. L., and Tenuta, A. 2022. Fungicide efficacy during a severe epidemic of tar spot on corn in the United States and Canada. Plant Health Progress. doi.org/10.1094/PHP-02-22-0012-BR.



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Coverage Matters!!!



Good

Poor

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5. **Timing is critical – can be too early or too late**

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Fungicide Timing – Indiana 2019, 2020, 2021

Fungicide: Trivapro 13.7 fl oz/A (benzovindiflupyr + azoxystrobin + propiconazole)

First detection of tar spot

2019

- V7 – 8 Jul **13 Jul**
- V9 – 15 Jul
- V10 – 19 Jul
- VT/R1 – 7 Aug
- R2 – 23 Aug
- V7 fb VT – 8 Jul, 7 Aug
- Tarspotter – no app

2020

- V8 – 14 Jul
- V10 – 20 Jul **28 Jul**
- VT/R1 – 7 Aug
- R2 – 21 Aug
- R3 – 2 Sep
- R4 – 11 Sep
- R5 – 23 Sep
- V8 fb VT – 14 Jul, 7 Aug
- Tarspotter – no app

2021

3 Jul

- V8 – 23 Jul
- V12 – 2 Aug
- R1 – 6 Aug
- R2 – 20 Aug
- R3 – 30 Aug
- R4 – 10 Sep
- R5 – 16 Sep
- V8 fb R1 – 23 Jul, 6 Aug
- Tarspotter – 2 Aug

Trials COR19-05/COR20-05/COR21-03
Location: PPAC
Hybrid: 'W25855SRIB'



V7-V12 Vegetative



VT-Tassel



R1-Silk



R2 - Blister



R3 - Milk



R4- Dough



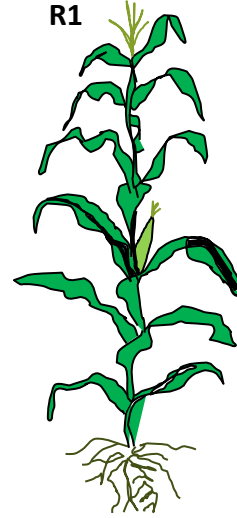
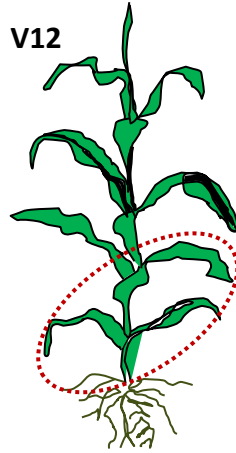
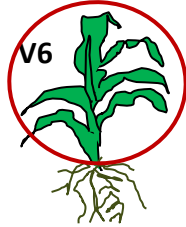
R5 - Dent

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*Photos courtesy of C. Gerber Dept. Agronomy

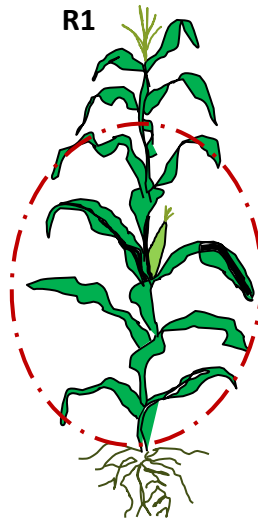
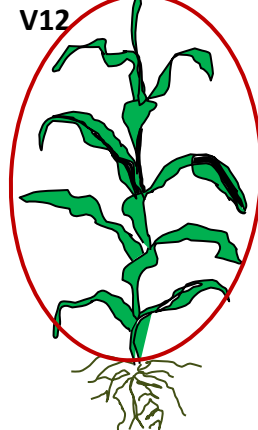
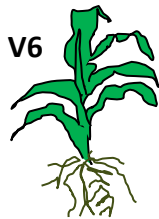


Putting things into perspective: Which leaves are protected?



IOWA STATE UNIVERSITY
Extension and Outreach

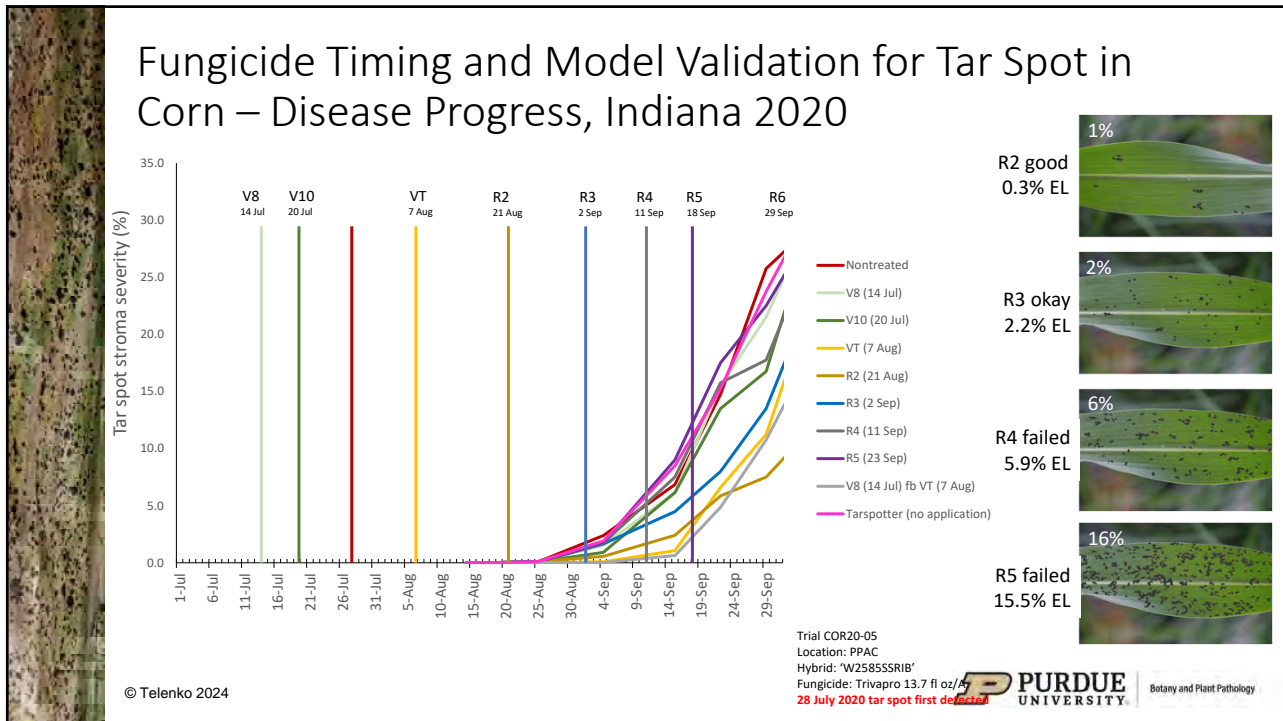
Which leaves are protected?

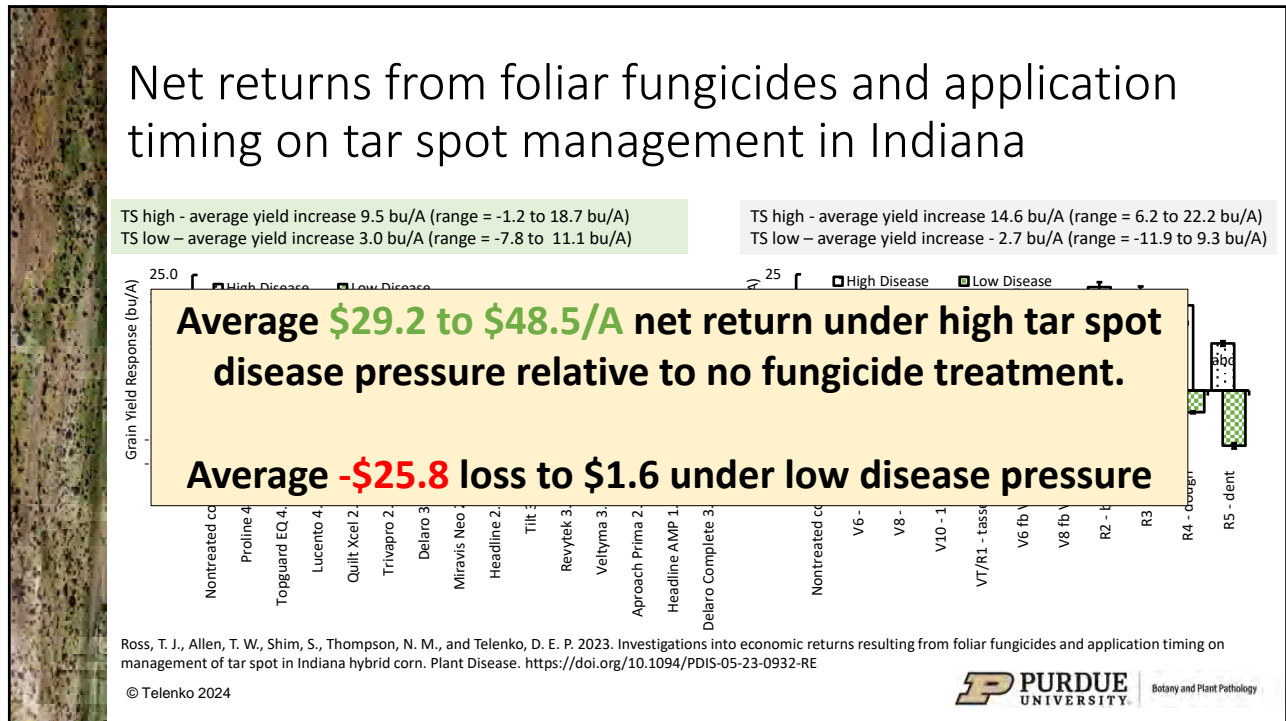
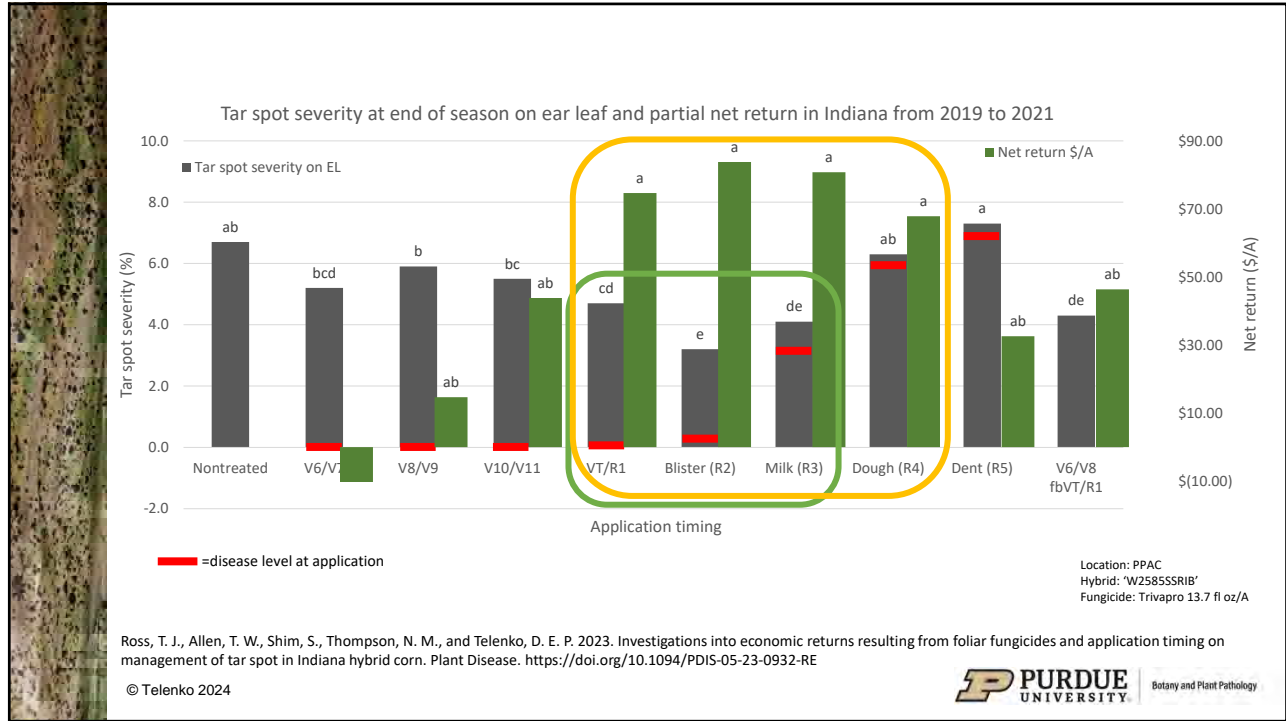


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Which leaves are protected?

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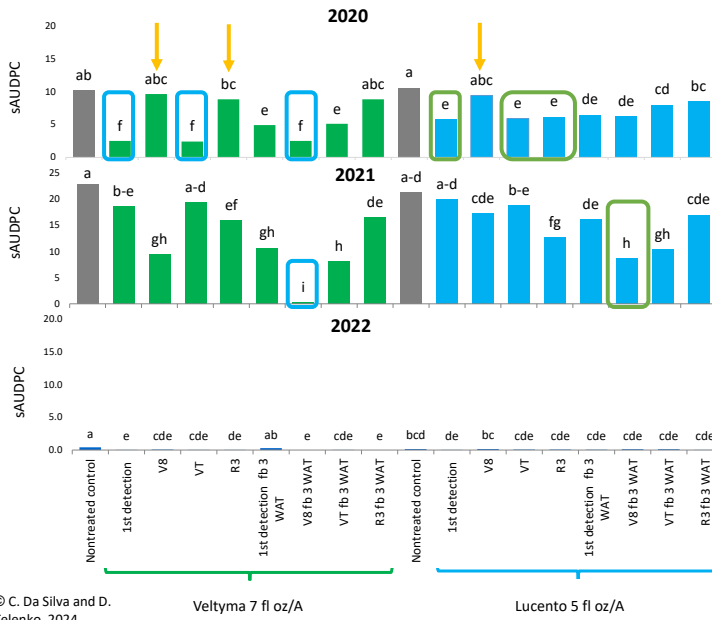


Break-even scenarios for corn

Bushels per acre needed to pay for application

Corn price (\$/bu)	Application cost (\$/A)				(Typically for two applications)				
	\$20	\$25	\$30	\$35	\$40	\$45	\$50	\$55	\$60
\$3.00	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0
\$4.00	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0
\$5.00	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
\$6.00	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0
\$7.00	2.9	3.6	4.3	5.0	5.7	7.9	7.1	7.9	8.6
\$8.00	2.5	3.1	3.8	4.4	5.0	5.6	6.3	6.9	7.5
\$9.00	2.2	2.8	3.3	3.9	4.4	5.0	5.6	6.1	6.7
\$10.00	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0

Fungicide Programs for Tar Spot in Corn



Trial COR20-15 P-value = 0.0001
 Location: PPAC
 Hybrid: 'W2585SSRIB'
28 July 2020 tar spot first detected
Average disease in nontreated at R6 was 40.7%

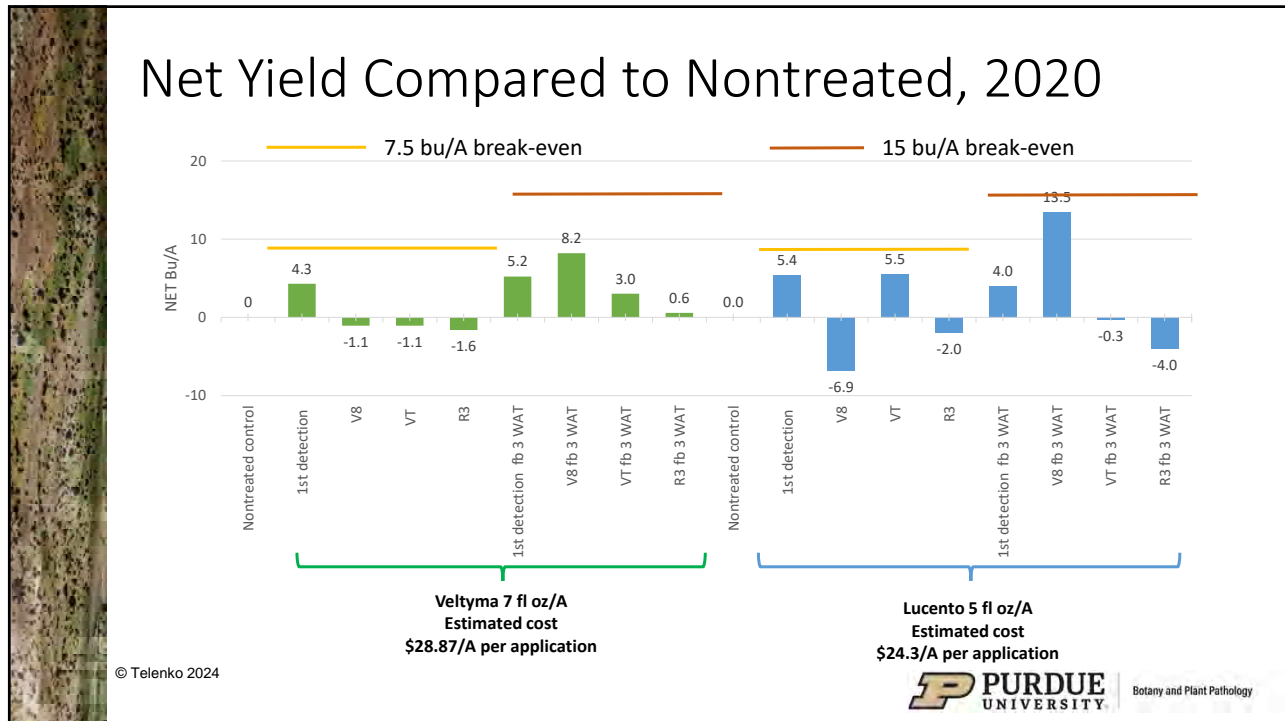
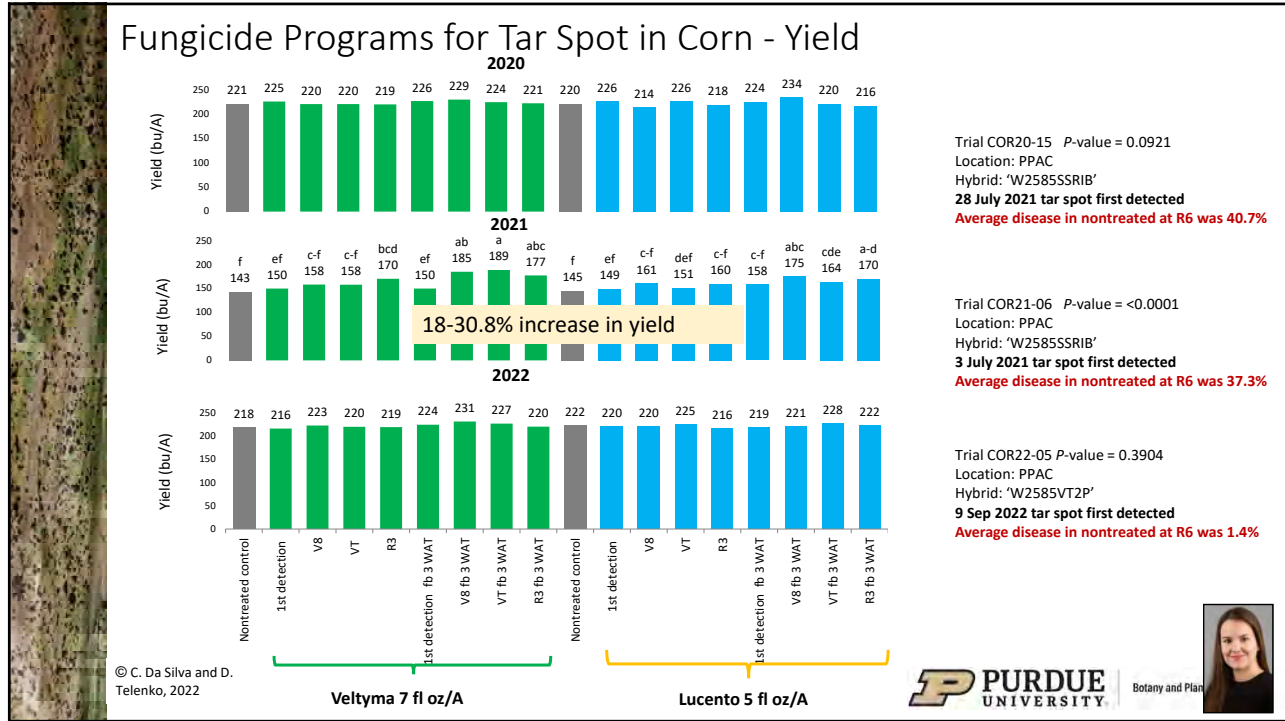
Trial COR21-06 P-value = 0.0001
 Location: PPAC
 Hybrid: 'W2585SSRIB'
3 July 2021 tar spot first detected
Average disease in nontreated at R6 was 37.3%

Trial COR22-05 P-value = 0.0001
 Location: PPAC
 Hybrid: 'W2585VT2P'
9 Sep 2022 tar spot first detected
Average disease in nontreated at R6 was 1.4%

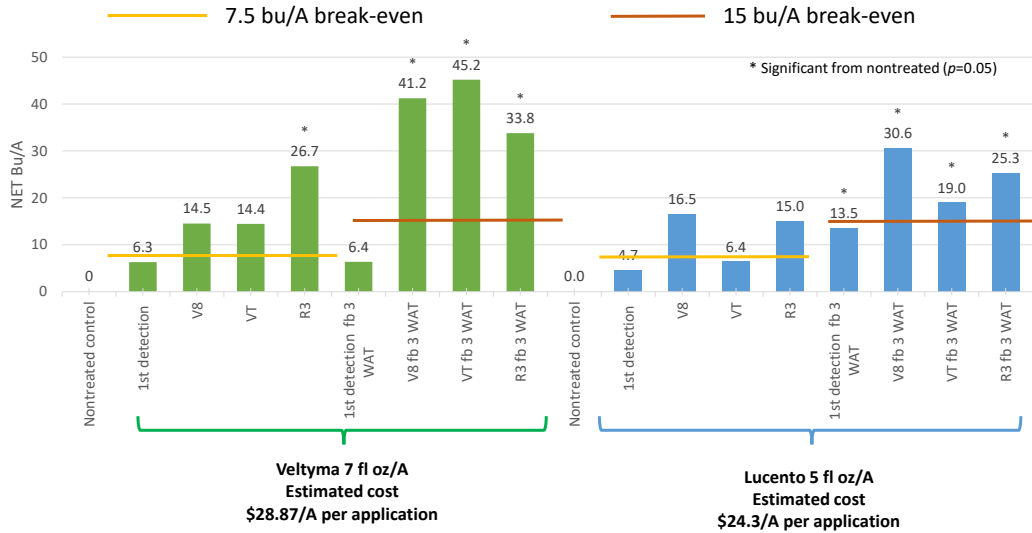


Trial COR21-06
 Location: PPAC
 Hybrid: 'W2585SSRIB'
3 July 2021 tar spot first detected





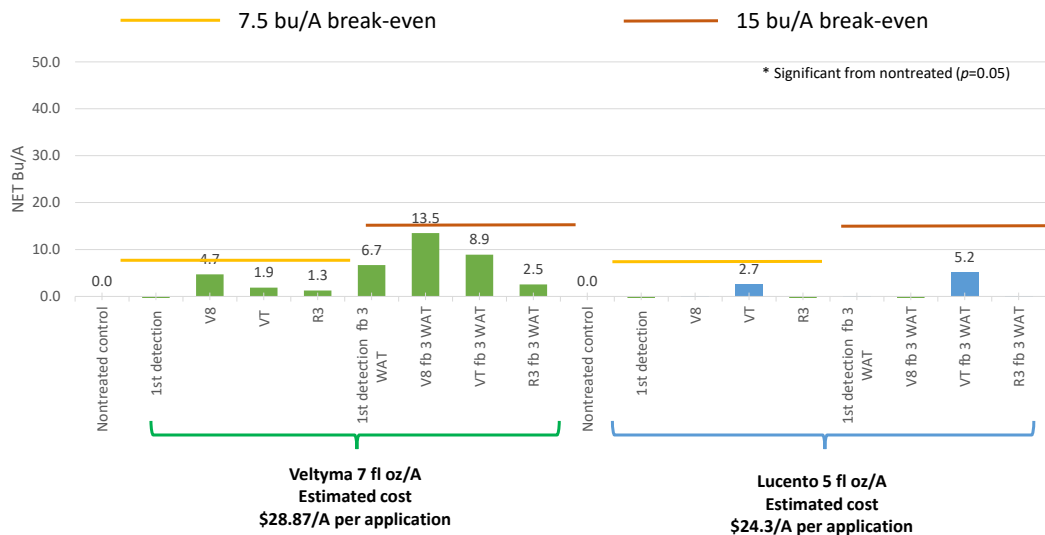
Net Yield Compared to Nontreated, 2021



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Net Yield Compared to Nontreated, 2022



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Uniform Fungicide Trials on Tar Spot 2022, 2023, 2024

Treatment, rate/A and timing^z

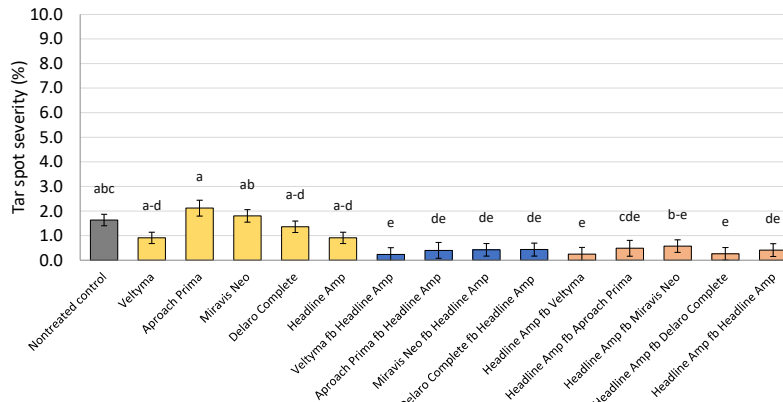
Nontreated control
Veltyma 7 fl oz at VT/R1
Approach Prima 6.8 fl oz at VT/R1
Miravis Neo 13.7 fl oz at VT/R1
Delaro Complete 8 fl oz at VT/R1
Headline AMP 10 fl oz at VT/R1
Veltyma 7 fl oz at VT/R1 fb Headline AMP 10 fl oz at 3WAT
Approach Prima 6.8 fl oz at VT/R1 fb Headline AMP 10 fl oz at 3WAT
Miravis Neo 13.7 fl oz at VT/R1 fb Headline AMP 10 fl oz at 3WAT
Delaro Complete 8 fl oz at VT/R1 fb Headline AMP 10 fl oz at 3WAT
Headline AMP 10 fl oz at VT/R1 fb Veltyma 7 fl oz at 3WAT
Headline AMP 10 fl oz at VT/R1 fb Approach Prima 6.8 fl oz at 3WAT
Headline AMP 10 fl oz at VT/R1 fb Miravis Neo 13.7 fl oz at 3WAT
Headline AMP 10 fl oz at VT/R1 fb Delaro Complete 8 fl oz at 3WAT
Headline AMP 10 fl oz at VT/R1 fb Headline AMP 10 fl oz at 3WAT

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Uniform Fungicide Trials on Tar Spot – Disease Severity 2022



2022 trials conducted in Indiana, Michigan, Wisconsin, Iowa and Ontario, CA (5 environments)
P= 0.0001

^z Values are least squares means. Values with different letters are significantly different based on least square means test ($\alpha=0.05$).
* Tar spot severity was rated by visually assessing the percentage of the symptomatic leaf area on the ear leaf at the mature growth stage (R6).

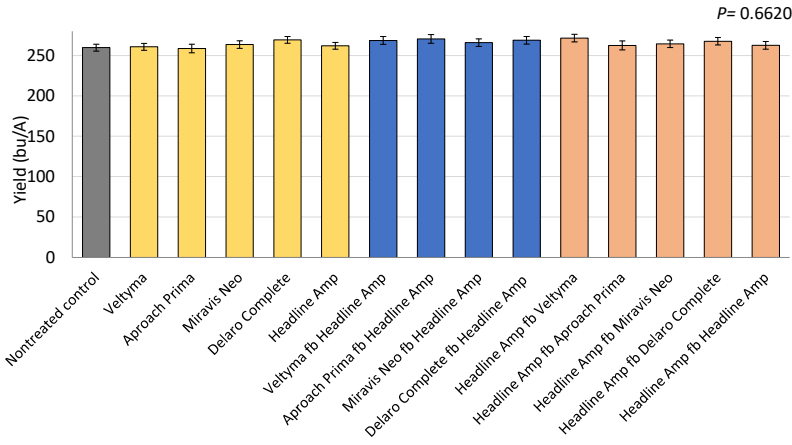
© M. Mizuno, D. Telenko, et. al. 2022

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Uniform Fungicide Trial on Tar Spot - Yield 2022



2022 trials conducted in Indiana, Michigan, Wisconsin, Iowa and Ontario, CA (5 environments)

^a Values are least squares means. Values with different letters are significantly different based on least square means test ($\alpha=0.05$).

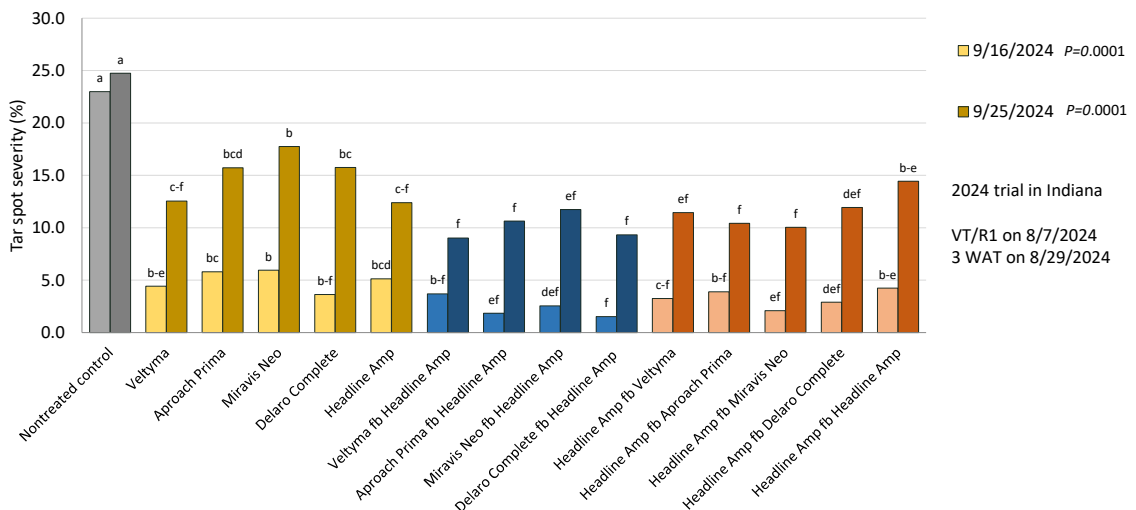
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Uniform Fungicide Trials on Tar Spot – Disease Severity Indiana 2024



9/16/2024 P=0.0001

9/25/2024 P=0.0001

2024 trial in Indiana

VT/R1 on 8/7/2024

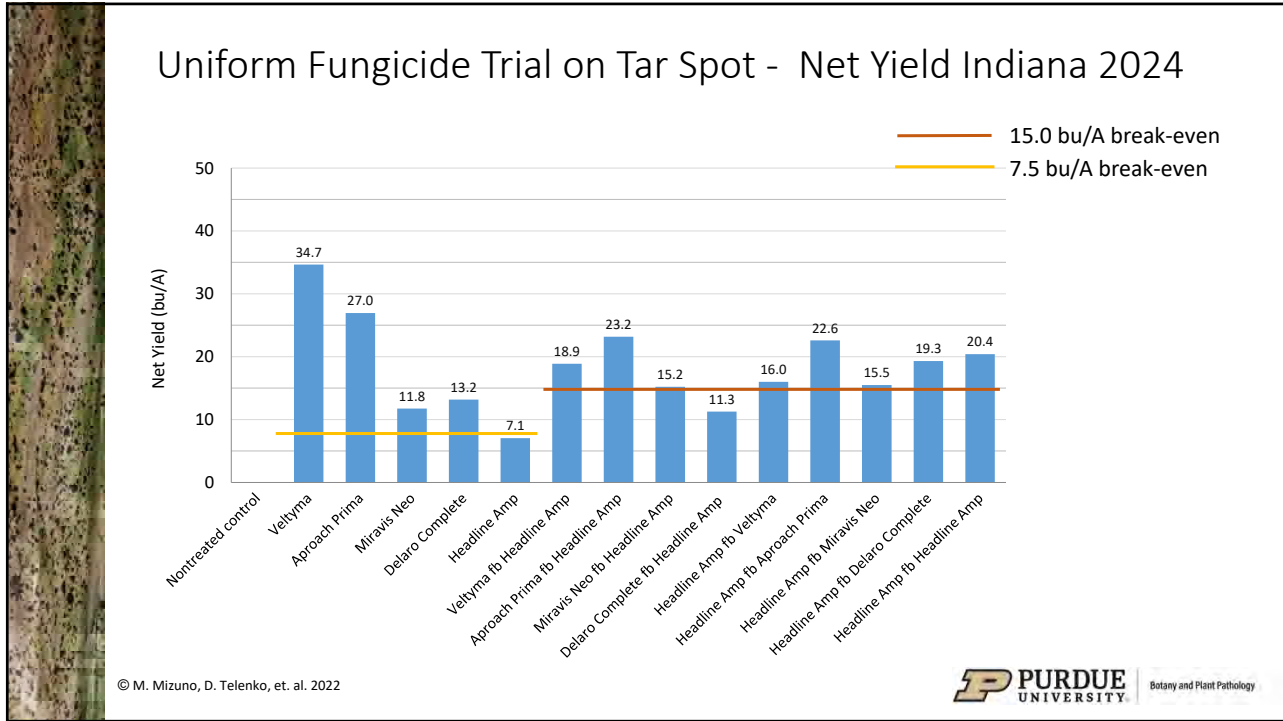
3 WAT on 8/29/2024

^a Values are least squares means. Values with different letters are significantly different based on least square means test ($\alpha=0.05$).

^b Tar spot severity was rated by visually assessing the percentage of the symptomatic leaf area on the ear leaf.

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Hybrid by Fungicide Timing Trials on Tar Spot Indiana 2022, 2023, 2024

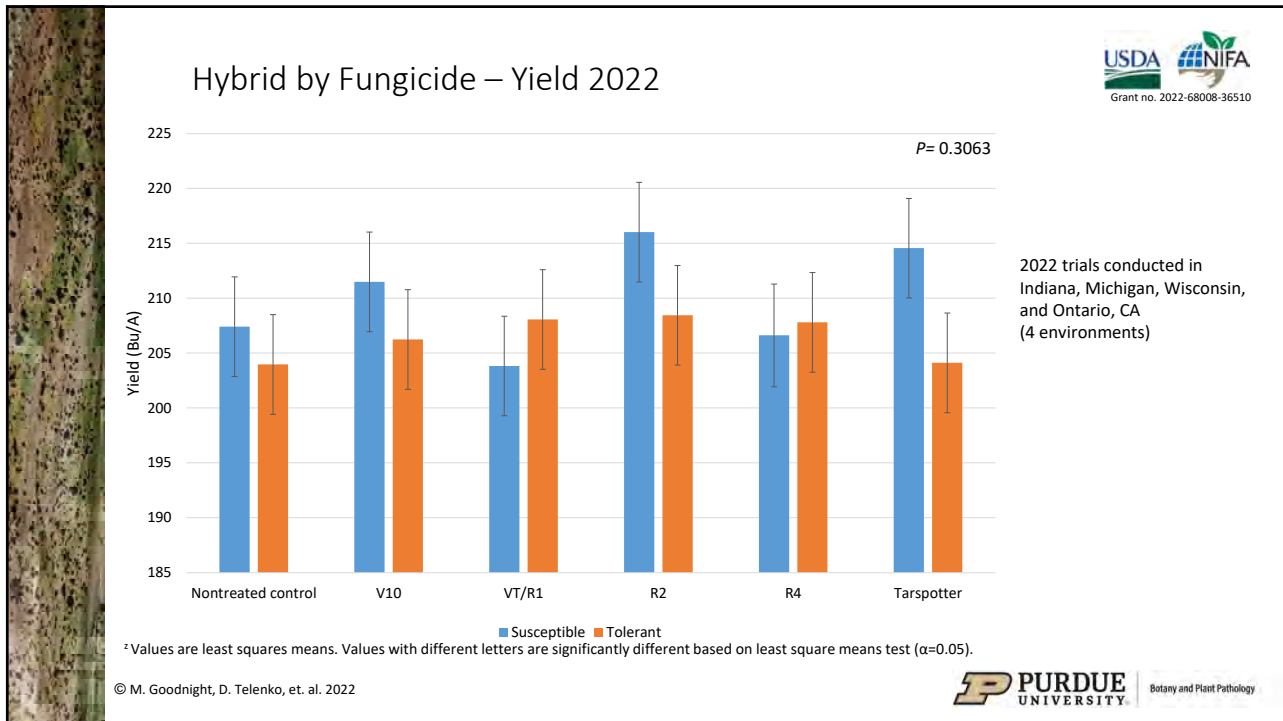
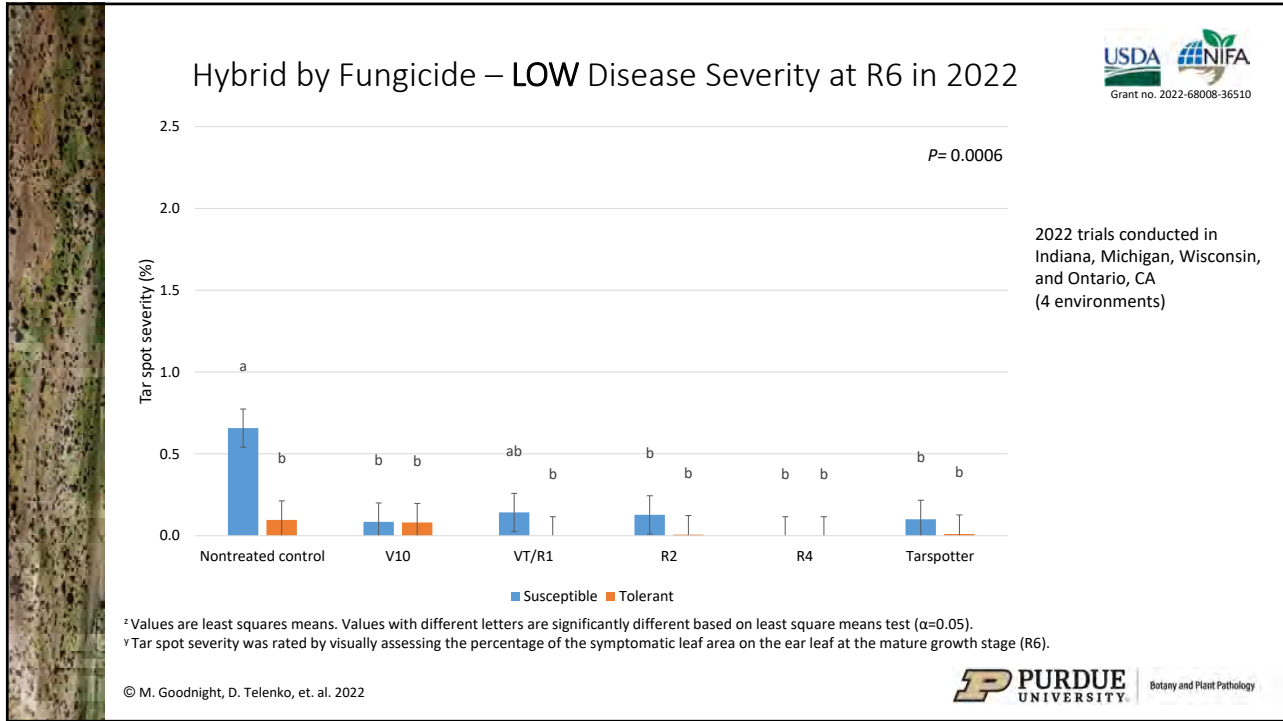
Hybrids	Dates 2022	Dates 2023	Dates 2024
Tar spot susceptible	planted 20 May	planted 18 May	planted 22 May
Tar spot tolerant	planted 20 May	planted 18 May	planted 22 May

Fungicide Programs	Dates 2022	Dates 2023	Dates 2024
Nontreated control			
Delaro Complete 8 fl oz/A at V10	21 Jul	25 Jul	12 Jul
Delaro Complete 8 fl oz/A at VT/R1	2 Aug	3 Aug	31 Jul
Delaro Complete 8 fl oz/A at R2	12 Aug	22 Aug	16 Aug
Delaro Complete 8 fl oz/A at R4	23 Aug	29 Aug	4 Sep
Delaro Complete 8 fl oz/A Tarspotter V8	14 Jul fb VT/R1 2 Aug R2 17 Aug fb R4 29 Aug R3 22 Aug fb R4 4 Sep		

Tar spot first detection	1 Sep	31 Jul
		15 Jul

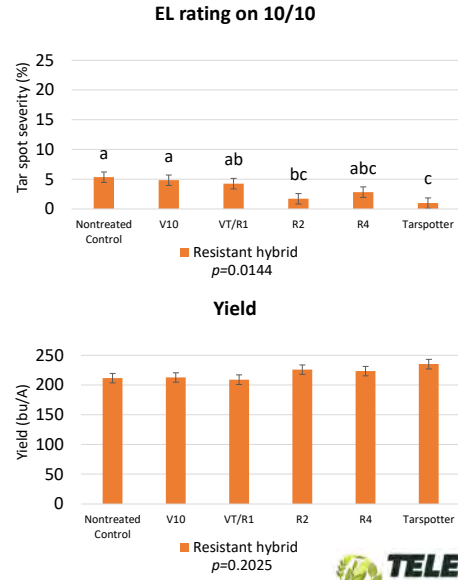
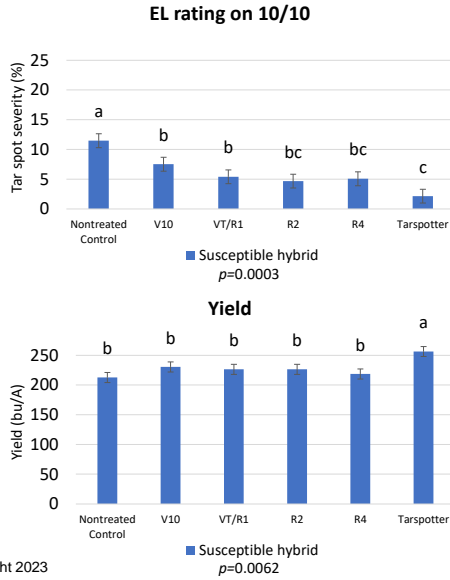
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Grant no. 2022-68008-36510





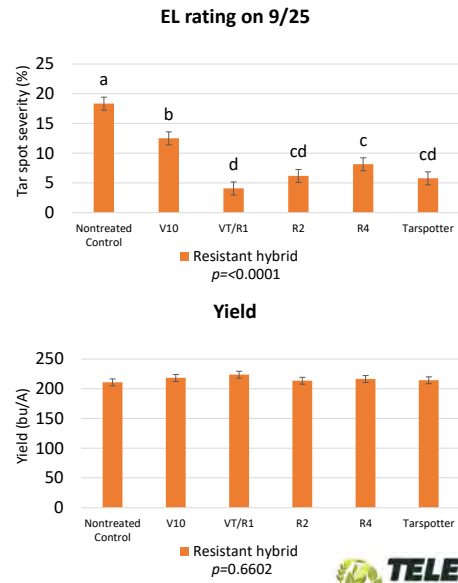
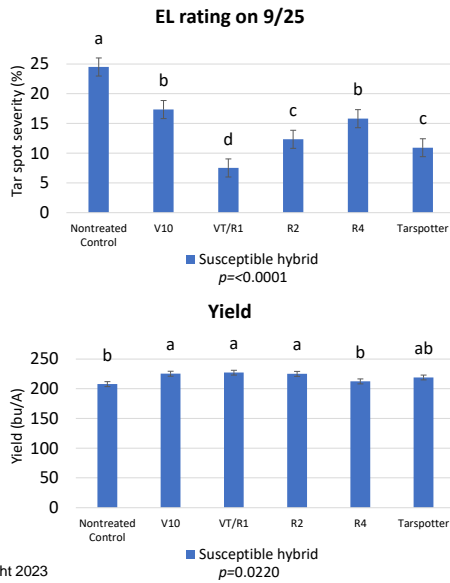
Hybrid by Fungicide – 2023



Goodnight 2023

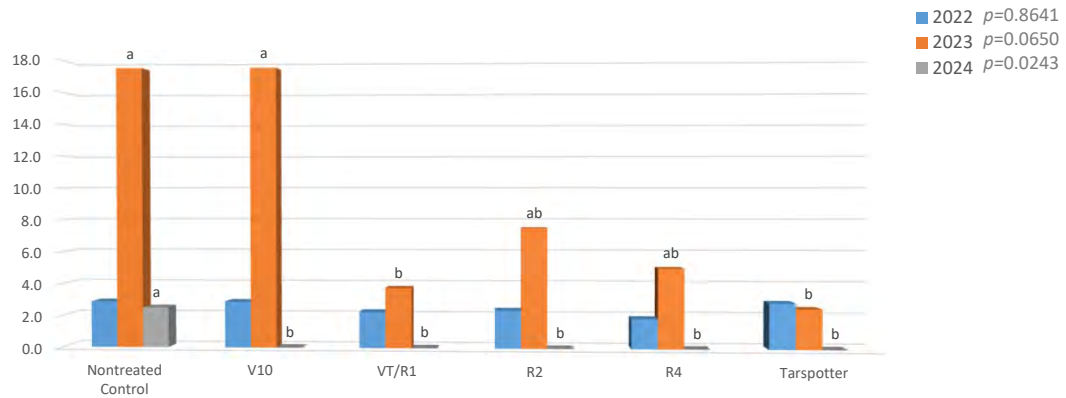


Hybrid by Fungicide – 2024



Goodnight 2023

Fungicide Timing on Lodging Risk



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My 10 Points after Seven Seasons of Tar Spot

1. Every year has been different – disease triangle!
2. Scouting is critical
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4. Fungicides will work, but tar spot shows limitations
5. Timing is critical – can be too early or too late
6. ROI – understand the numbers on 1x vs. 2x applications
- 7. Corn will never be 100% clean at the end of the season – see #4**
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Survives in Corn Residue – Impact?



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Foliar Fungicide Classes in Field Crops

Fungicide Resistance Action Committee (FRAC) Codes and Risk for Developing Resistance

FRAC CODE	Fungicide group	Risk of Developing Resistance
1 (soybean only)	Methyl benzimidazole carbamates (MBC)	High
3	Demethylation inhibitors (DMI, triazoles)	Medium
7	Succinate dehydrogenase inhibitors (SDHI)	Medium to High
11	Quinone outside inhibitors (QoI, strobilurins)	High

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Why does it matter?

- Stewardship of fungicides
- ROI
- Changes with ESA and pesticide use
- One Health Initiative
 - 2.8 million antimicrobial-resistant infections, and >35,000 deaths each year
 - Triazoles (DMI) used on crops = azoles used in humans & animals

Endangered Species Act

- All Federal Agencies must ensure that their actions do not:
 - Jeopardize **species** existence; or
 - Destroy or adversely modify designated **critical habitat**
- Federal agencies must **consult** if an action may affect a listed species or its designated critical habitat



USDA EPA

EPA United States Environmental Protection Agency

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Pesticides

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A-Z Index
Bed Bugs
Antimicrobial Pesticides
Biopesticides
Freedom of Information Act Requests
International Activities Related to Pesticides
Pest Control and Pesticides

Feedback Requested on Structure and Scope for Proposed Framework to Strengthen Assessment of Antimicrobial-resistance Risks Associated with Pesticide Use

Released on September 26, 2023



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Extension and Outreach

Follow the RULES to prevent fungicide resistance

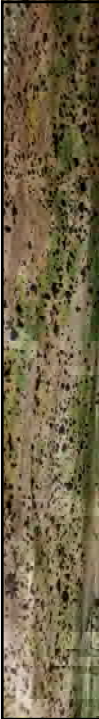
R	Rotate or pre-mix fungicides of different groups.
U	Use labeled rates and at times of critical disease control.
L	Limit number of applications of any fungicide group in growing season.
E	Educate yourself about fungicide groups and resistance management tactics.
S	Select fungicides that are effective and/or have multiple sites of activity.

Adopted from J.W. Pscheidt, OSU

My 10 Points after Seven Seasons of Tar Spot

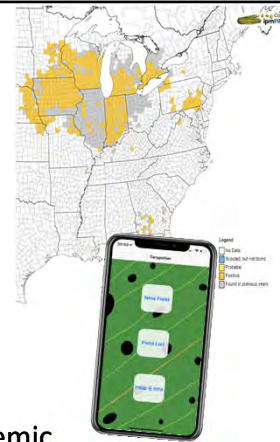
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Recommendations: Tar Spot Disease Management

- **Assess risk – is it endemic in your area? Scout!!**
- **Talk to your seed salesperson about hybrid resistance**
- **Consider fungicides**
 - Mixed mode of action
 - **Timing very important, use maps and apps**
 - Application will need to occur close to the onset of the epidemic
 - If applying fungicides be sure to leave check strips
- **Manage irrigation**
- ~~Rotate to other crops and residue management~~ **Less effective for tar spot**



Fungicide Efficacy for Control of Corn Diseases Table

Fungicide	Mode of Action	Product	Application Timing	DM (%)	Yield (bu/acre)	Stalk N (lb/acre)	Stalk DM (%)	Stalk N (lb/acre)	Stalk DM (%)	Stalk N (lb/acre)	Stalk DM (%)
Prothioconazole	DMIT	Prothio	VT	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Prothioconazole + Tebuconazole	DMIT + SDHI	Prothio + Tebu	VT	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Prothioconazole + Tebuconazole + Triflurofenox	DMIT + SDHI + QoI	Prothio + Tebu + Triflu	VT	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Telenko, D., Chilvers, M., Kleczewski, N., Mueller, D., Plewa, D., Robertson, A., Smith, D., Tenuta, A., and Wise, K. 2020. Tar Spot. CPN 2012-W. doi.org/10.31274/cpn-20190620-008.
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Fungicide Timing for Tar Spot

Crop Stage When Tar Spot is First Detected	Possible Benefit From Spraying	Comment
Late Vegetative	Rarely, consult extension specialists before spraying	Scout fields and monitor disease progress; may need a second spray
VT/R1 (Tasseling/Silking)	Yes	May need a second spray
R2 (blister)	Yes	Less likely to need a second spray
R3 (milk)	Yes	No second spray needed
R4 (dough)	Maybe, with severe disease pressure	No second spray needed
R5 (dent)	No	No second spray needed
R6 (black layer)	No	No second spray needed

<https://cropprotectionnetwork.org/maps/tar-spot-of-corn>

CropProtectionNetwork.org



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Fungicide Efficacy Resource for Corn

Fungicide mode of action groups:
 Group 11 Qol/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)	Anthraxnose leaf blight	Common rust	Eye spot	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
Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 – 12.0	VG	E	E	E	VG	VG	NL	7 days
Picoxystrobin	Approach 2.08 SC	3.0 – 12.0	VG	VG-E	VG	F-VG	VG	G	G ³	7 days
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
Prothioconazole 41.0%	Proline 480 SC	5.7	U	VG	E	U	VG	G	NL	14 days
Tebuconazole 38.7%	Folicur 3.6 F, multiple generics	4.0 – 6.0	NL	U	NL	U	VG	F	NL	36 days
Tetraconazole 20.5%	Domark 230 ME	4.0 – 6.0	U	U	U	E	VG	G	G-VG ³	R3 (milk)
11 Azoxystrobin 13.5%	Quilt Xcel 2.2 SE, multiple generics	10.5 - 14.0	VG	VG-E	VG-E	E	VG	VG	G-VG ³	30 days
3 Propiconazole 11.7%										
7 Benzovindiflupyr 2.9%										
11 Azoxystrobin 10.5%	Trivapro 2.21 SE	13.7	U	U	U	E	VG	E	G-VG	30 days
3 Propiconazole 11.9%										
3 Cyproconazole 7.17%										
11 Picoxystrobin 17.94%	Approach Prima 2.34 SC	3.4 – 6.8	U	U	U	E	VG	G	G-VG ³	30 days

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Fungicide ROI Tool

<https://cropprotectionnetwork.org/fungicide-roi-calculator>

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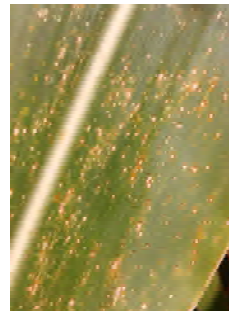
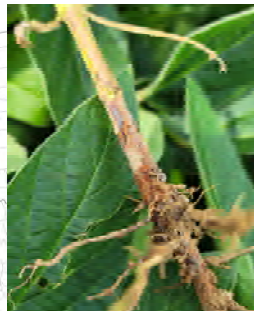
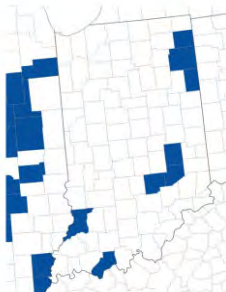
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Diseases to Watch For

- Red crown rot soybean
- Curvularia leaf spot corn
- Corn stunt (1 confirmation in 2024)



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Acknowledgements



This project was supported by Agriculture and Food Research Initiative Competitive Grant no. 2022-68008-36510 from the USDA National Institute of Food and Agriculture.

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QUESTIONS?

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<https://indianafielddcroppathology.com/>

