

NEW AND EMERGING DISEASES IN FIELD CROPS: TAR SPOT OF CORN

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Tar Spot of Corn

What is it?

Should you be worried?

What to do?

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Tar Spot Complex – Latin America

- A major foliar disease of maize in Latin America
 - First documented in Mexico-1904
- 50% yield losses in susceptible hybrids and conducive conditions
- Believed to result from activities of two fungi:
 - *Phyllachora maydis*
 - *Monographella maydis*

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Tar Spot Complex : TSC

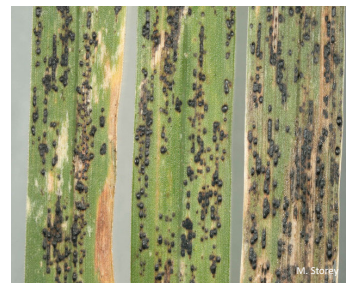


Mottaleb, K.A., Loladze, A., Sonder, K. et al. Mitig Adapt Strateg Glob Change (2018). <https://doi.org/10.1007/s11027-018-9812-1>

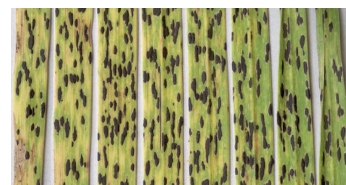


Phyllachora spp.

- Currently 994 species
- Obligate biotrophs
- Named after host association
- Still confusion regarding species concepts
 - most species defined by morphology only
- Typically have narrow host range



P. dactylidis (on orchard grass)

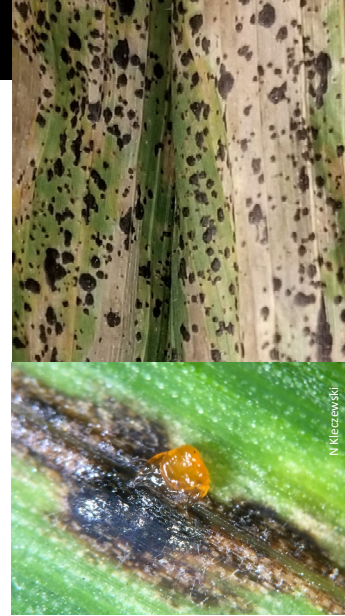


P. graminis (on multiple grass species)



Phyllachora maydis

- Only known *Phyllachora* species to infect maize
- Produces raised stromata on foliage, husks
 - Black
 - Vary from small, oval “pin heads” to more elongated stromata
 - May or may not have necrotic area surrounding stromata
- Ascospores exuded in mucilaginous substance
- Conidia (*Linochora* spp.) also may be released from stromata.
 - Spermata?
 - Infect alternate host?
- Not believed to be seed borne



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Tar Spot of Corn - Identification

Causal agent: *Phyllachora maydis*



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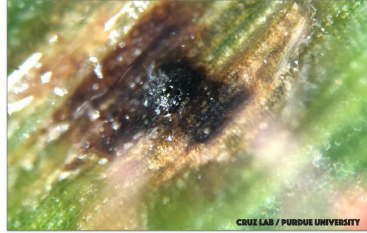
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Stroma and Spore Production



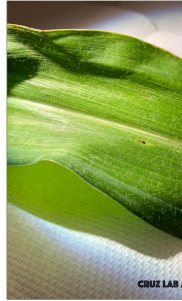
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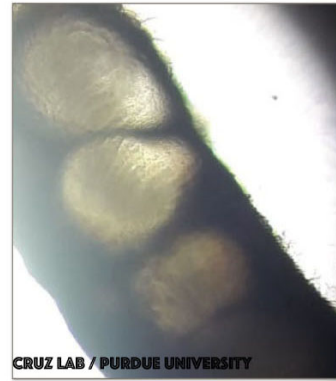
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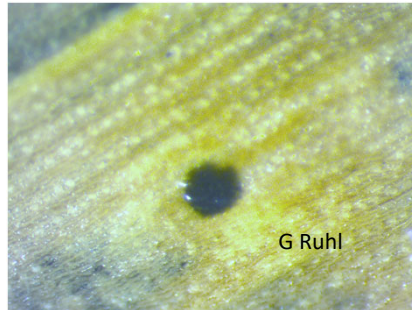
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Look Alike Disorders

- Insect frass



- Physoderma brown spot



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Look Alike Disorders

- Mature/old southern or common rust



- Saprophytic fungi



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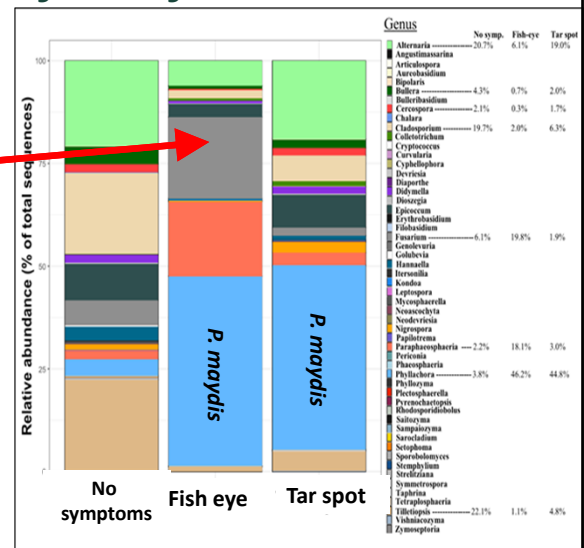
Tar spot – fisheye symptom

- *Monographella maydis* has **not** been **identified** in U.S.
- We do see the fisheye symptom once in a while – 2019 in Indiana it appeared later in the season
- Causes??

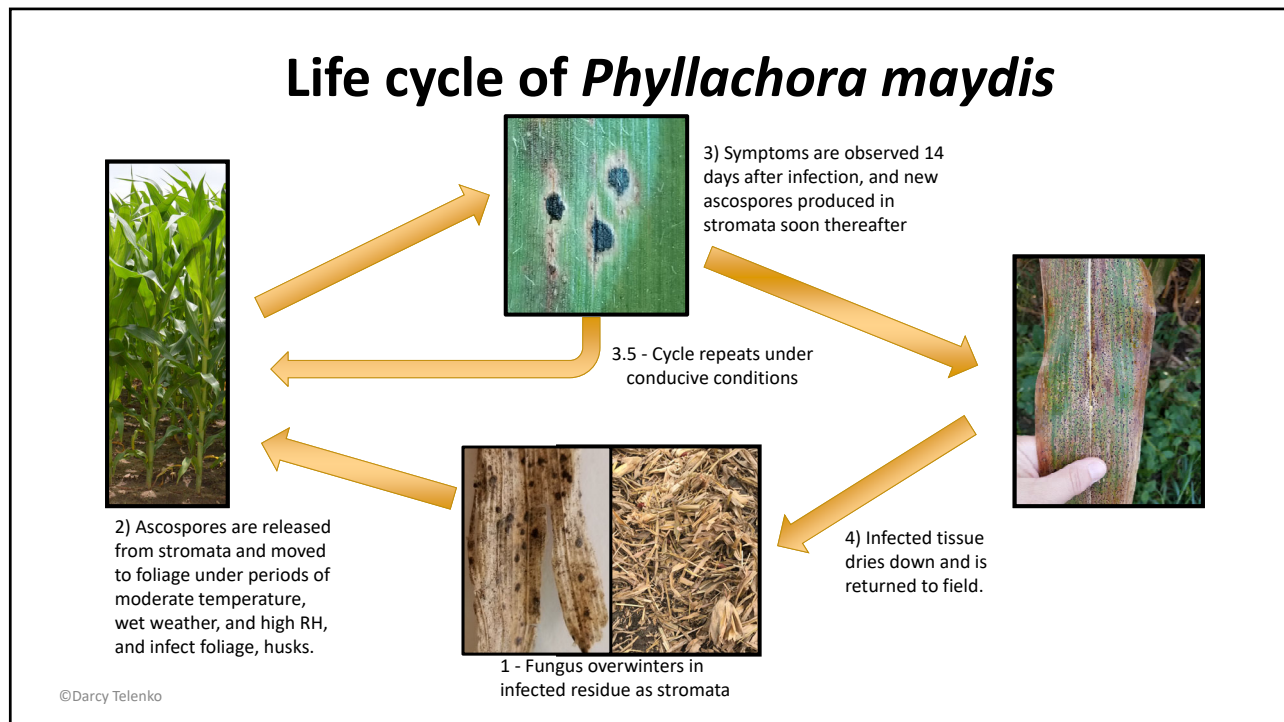


Tar Spot Fungal Community Study 2018

- *Neottiosporina paspali* – significantly more abundant in fish-eye lesions
- *Fusarium* – present in fish-eye hard to differentiate from *Monographella*
- *Paraphaeosphaeria neglecta* (*Coniothyrium*-like - mycoparasite) present as indicator species of fish eye



McCoy AG, Roth MG, Shay R, Noel ZA, Jayawardana M, Longley RW, Bonito G, Chilvers MI (2019) Identification of fungal communities within the tar spot complex of corn in Michigan via next generation sequencing. Phytobiomes J 1-9



Tar Spot Epidemic in the U.S. - 2018



2018 epidemic - Severe corn grain, silage quality and yield losses of more than 30 bushels per acre



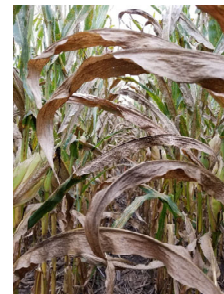
Disease incidence -100%, over 50% severity on corn ear leaf (GS R5/R6 dent corn)



All hybrids - susceptible to *P. maydis* infection at varying levels of severity.

Tar spot is presently documented in **9 states**:

- Illinois
- Indiana
- Iowa
- Michigan
- Minnesota
- Missouri
- Ohio
- Wisconsin
- Florida



(Kleczewski et al. 2019; Mottaleb et al. 2019, Telenko et al. 2019)

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Economic Impact of Tar spot



Reduce the yield of corn grain, husks and silage quality.



Corn grain yield loss can range between 11 to 46 percent.



Yield loss is dependent on corn genotype susceptibility, presence of favorable environmental factors, and the severity of tar spot epidemics.



Recently tar spot has caused economic concerns in U.S. corn production.

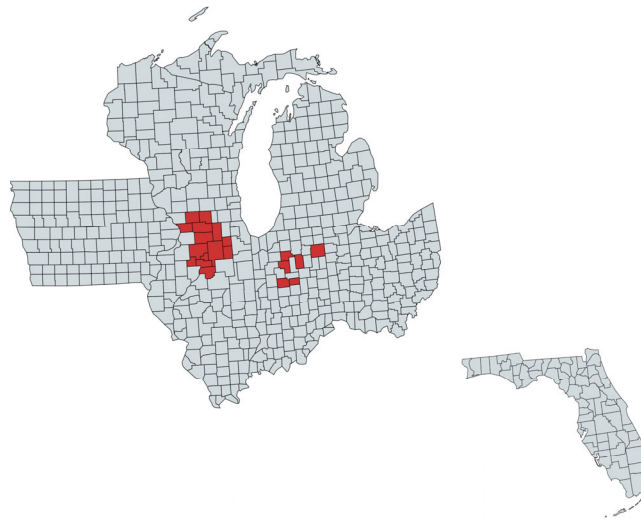
(Maublanc, 1904, Bajet et al. 1994, Hock et al. 1989, Pereyda-Hernández et al. 2009, Mottaleb et al. 2019, Telenko et al. 2019).

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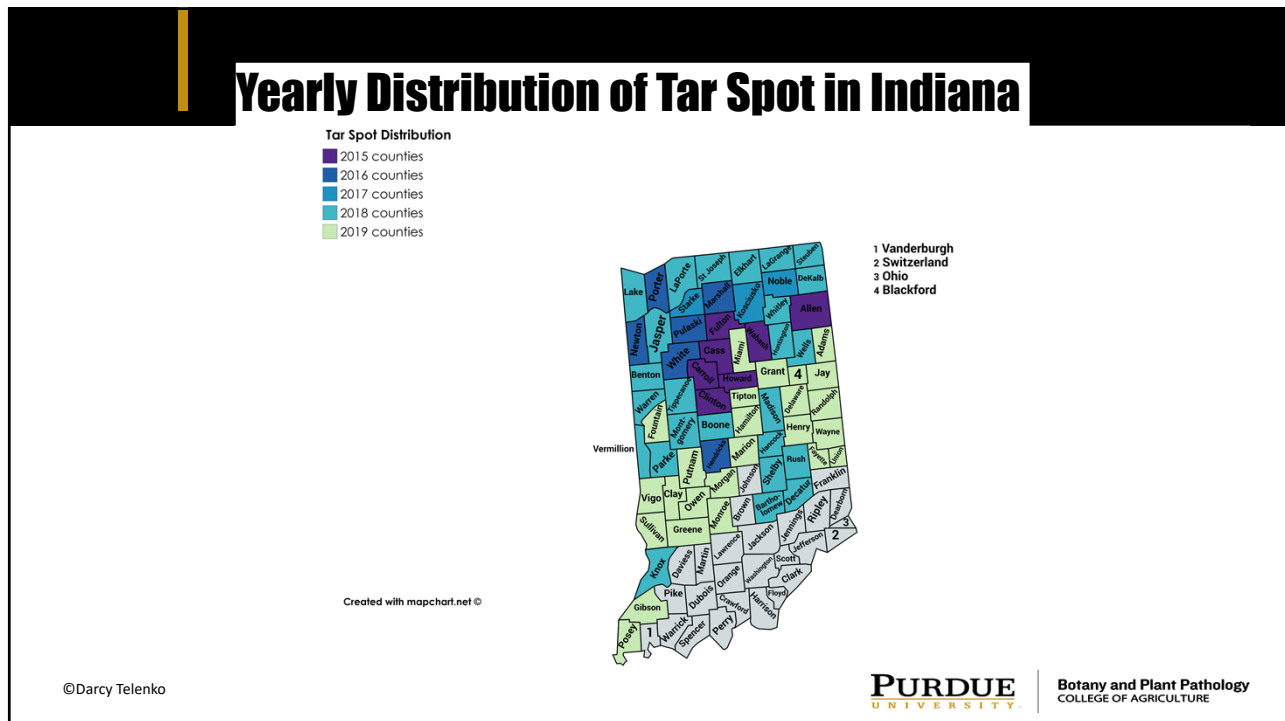
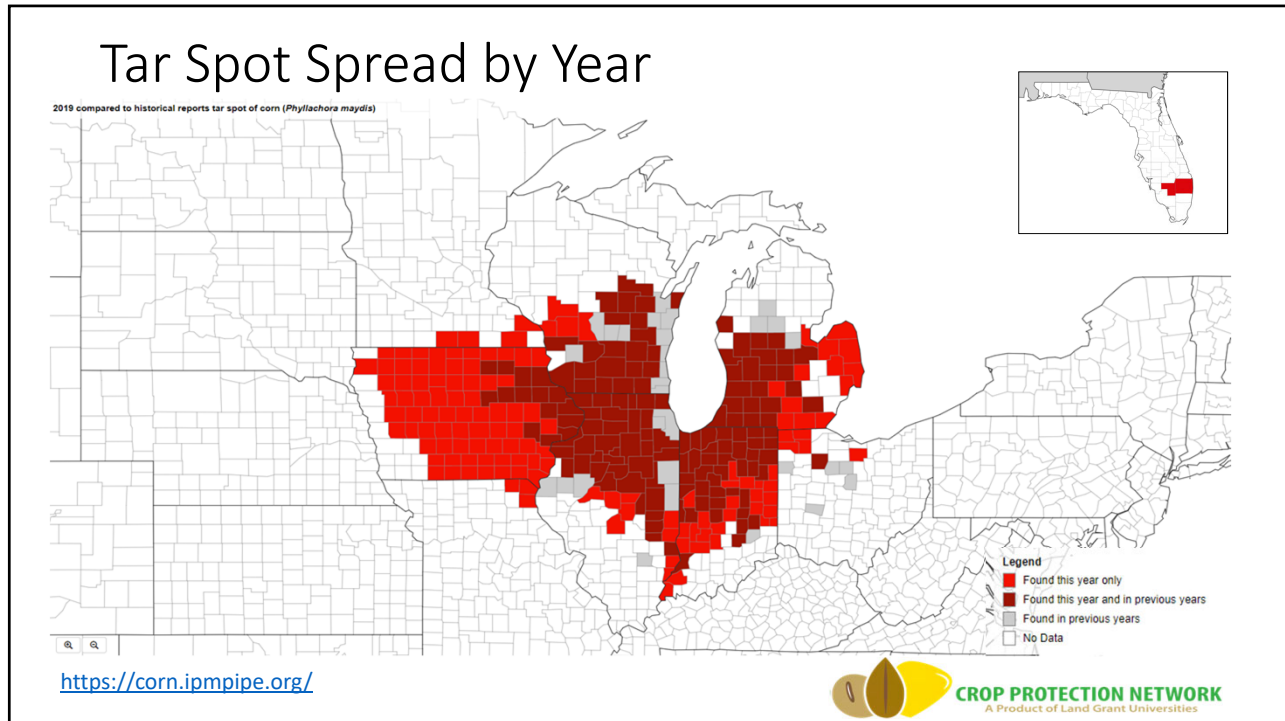
Corn Tar Spot in the US - 2015



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Range of Leaf Severity of Tar Spot

>25 % severity on leaf



5-7 % severity on leaf



1 % severity on leaf



<1 % severity on leaf



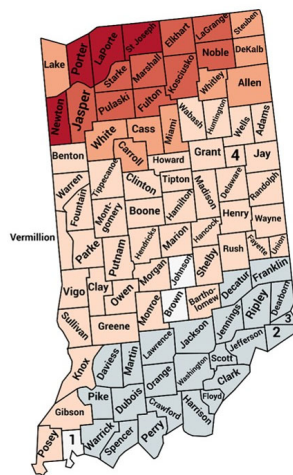
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Map Tar Spot Index for Indiana – 2019

- Tar spot 2019**
- Tar Spot Index > 15
 - Tar Spot Index 5-15
 - Tar Spot Index 1-4.9
 - Tar Spot Index >0 and <1
 - Tar Spot Not Found



- 1 Vanderburgh
- 2 Switzerland
- 3 Ohio
- 4 Blackford

148 fields scouted in 68 counties – 132 fields in 65 counties with tar spot (89.2%)

©D. Telenko, Purdue University

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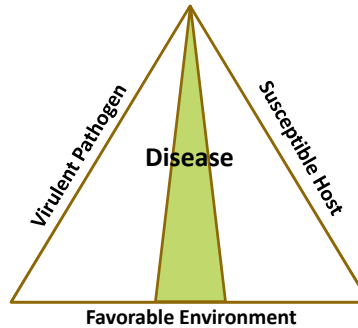


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Disease Triangle

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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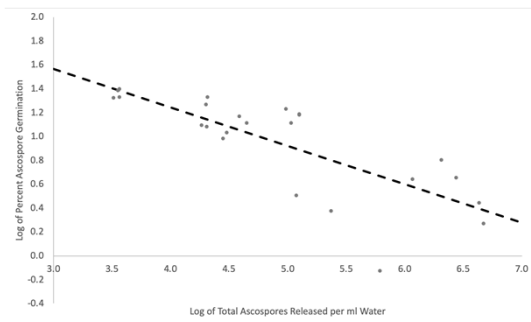
Can the Tar Spot Pathogen Overwinter in the Midwest?

Sample	4 hr		24 hr	
	Mean Total ascospores ¹	Mean Spore Germination (%) ²	Mean Total ascospores ¹	Mean Spore Germination (%) ²
IL2	4,773,333 a	1.9 ef	4,379,000 a	2.8 c
IL3	2,065,000 a	6.3 cd	2,790,667 a	4.5 c
IL1	617,333 b	0.7 f	1,167,000 b	4.4 c
WIS2	126,800 c	15.3 ab	126,322 cd	15.0 ab
MI1	118,856 c	3.2 de	237,156 c	2.4 c
INE3	107,078 c	12.9 abc	97,944 de	17.0 ab
INA4	38,811 d	14.6 ab	44,822 ef	12.8 ab
WIA1	30,278 d	10.7 bc	28,033 fg	9.5 b
WIS1	20,556 d	12.1 abc	18,378 g	12.4 ab
INB4	20,167 d	18.5 ab	20,789 fg	21.2 a
WIA2	3,689 e	21.3 ab	3,289 h	20.9 a
INB1	3,556 e	24.1 a	3,700 h	24.9 a

¹Mean total ascospores released after incubation in water for 4 or 24 hours. Different letters after each value indicate that mean is different based on Fisher's protected least significant difference (LSD) at $\alpha=0.05$.

²Mean percent ascospores germinated after incubation in water for 4 or 24 hours. Different letters after each value indicate that mean is different based on Fisher's protected least significant difference (LSD) at $\alpha=0.05$.

Figure 1. Relationship of log of total ascospores released per milliliter of water and the log of percent ascospores germinated after 4 or 24 hours of incubation in water.

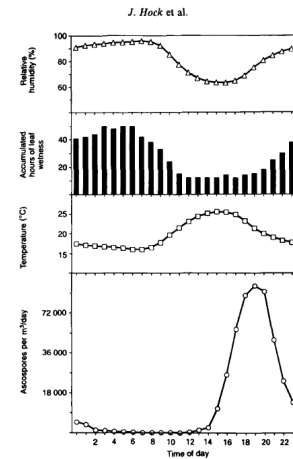


Data from: Groves, C.L., Kleczewski, N.M., Telenko, D.E.P., Chilvers, M.I., and Smith, D.L. 2019. *Phyllachora maydis* ascospore release and germination from overwintered corn residue. Plant Health Progress. *Accepted*

Phyllachora maydis biology in Latin America

- Disease favored by cool , wet conditions
 - 60-70 F
 - 7 hrs of leaf wetness at night
- Spores released predominantly at night under high RH
- Spores can disperse at least 75 m (approx. 250 ft) from source
- Overwinters in residue as stroma with ascospores
 - Common in this genus

J. Hock, Kranz, J, and B.L. Renfro. 18995. Studies on the epidemiology of the tar spot disease complex of Maize in Mexico. Plant Pathology 44: 490-502.



Mean catches of ascospores of *P. maydis* per hour in relation to average hourly temperature, RH, and leaf wetness duration over 80 days in 1987. From Hock et al, 1995.



Disease Management for Field Crops

- Genetic resistance
- Crop rotation
- Sanitation
 - Eliminate Inoculum in Infected Field
 - Fall Tillage
 - Avoid Spread of Inoculum
 - Clean machinery between known infected fields
- Pesticide application (fungicide)

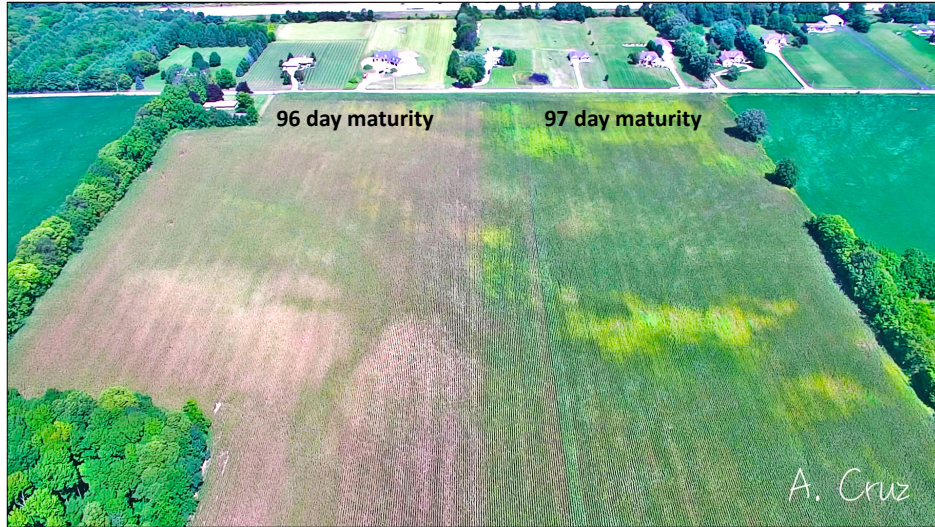
Host

Host/Pathogen

Pathogen

Pathogen/Host

St. Joseph County – End of August 2019



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Variability of Hybrid Susceptibility



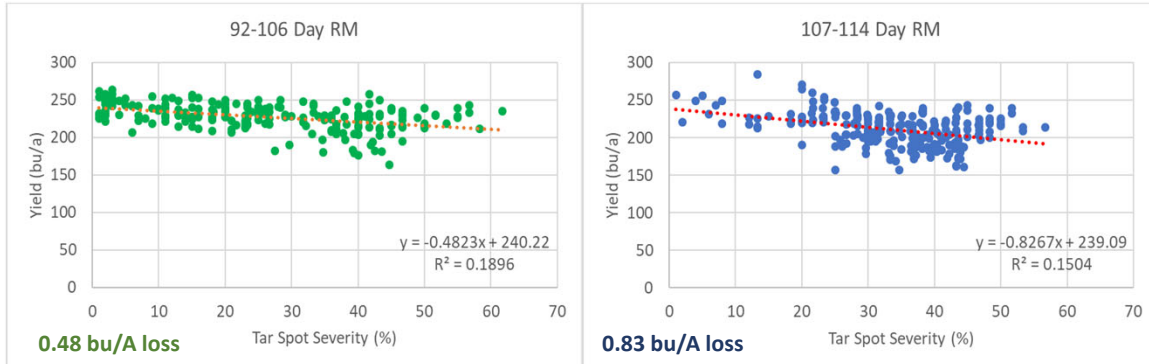
Photo Courtesy of Darcy Telenko, Purdue

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Impact of Tar Spot Severity on Ear Leaf on Corn Hybrid Yield



Illinois, Indiana, Michigan and Wisconsin performance trials. Corn hybrids were grouped by relative maturity (92-106 day and 107-114 day).

Telenko, D. E. P., Chilvers, M. I., Kleczewski, N., Smith, D. L., Byrne, A. M., Devillez, P., Diallo, T., Higgins, R., Joss, D., Lauer, J., Muller, B., Singh, M. P., Widdicombe, W. D., and Williams, L.A. 2019. How tar spot of corn impacted hybrid yields during the 2018 Midwest epidemic. Crop Protection Network. doi.org/10.31274/cpn-20190729-002



Summary from University Hybrid Trials -2018

Illinois, Indiana, Michigan, and Wisconsin

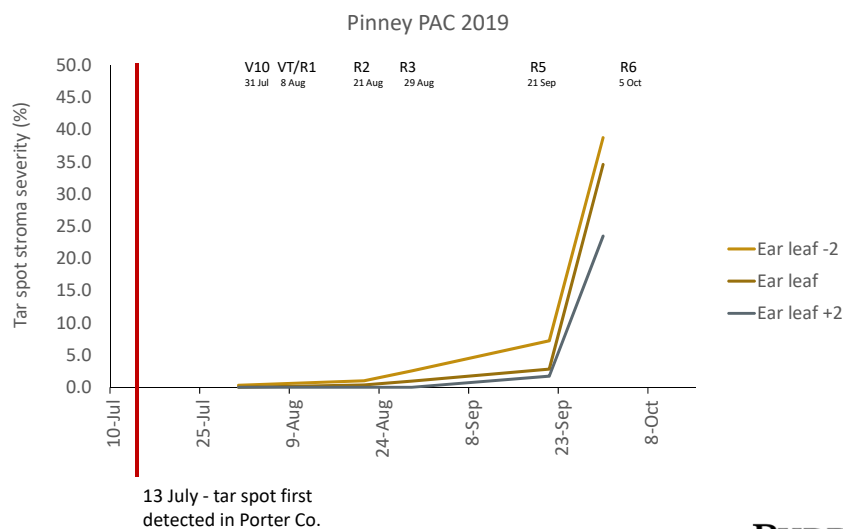
- A range in hybrid susceptibility and reaction to tar spot
- 0.32–1.36 bu/A loss occurred per 1% increase in tar spot.
- Maturity may influence susceptibility and yield
- 1% increase in tar spot severity on the ear leaf –
 - 0.48 bu/A yield loss for hybrids with 92-106 RM
 - 0.83 bu/A yield loss for hybrids with 107-114 RM
- Fields that experience 40-50% tar spot severity on the ear leaf by R5/R6 saw a loss of 16.8 to 38.7 bu/A (1130 to 2605 kg/ha)
- Growers' reports from regions with severe infections reporting losses of 20 to 60 bu/A (1345 to 4035 kg/ha).

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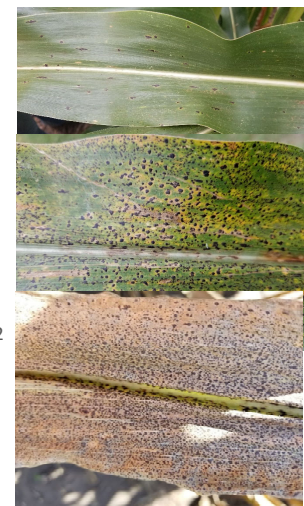
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Tar Spot Development in Non-Treated Canopy, Indiana 2019

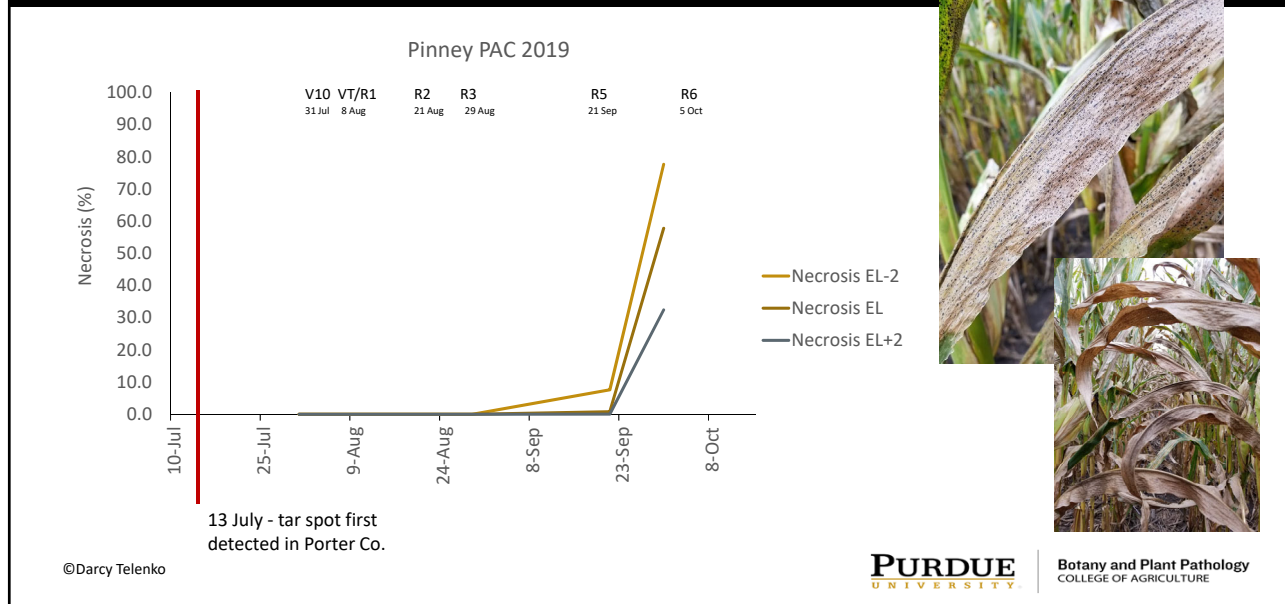


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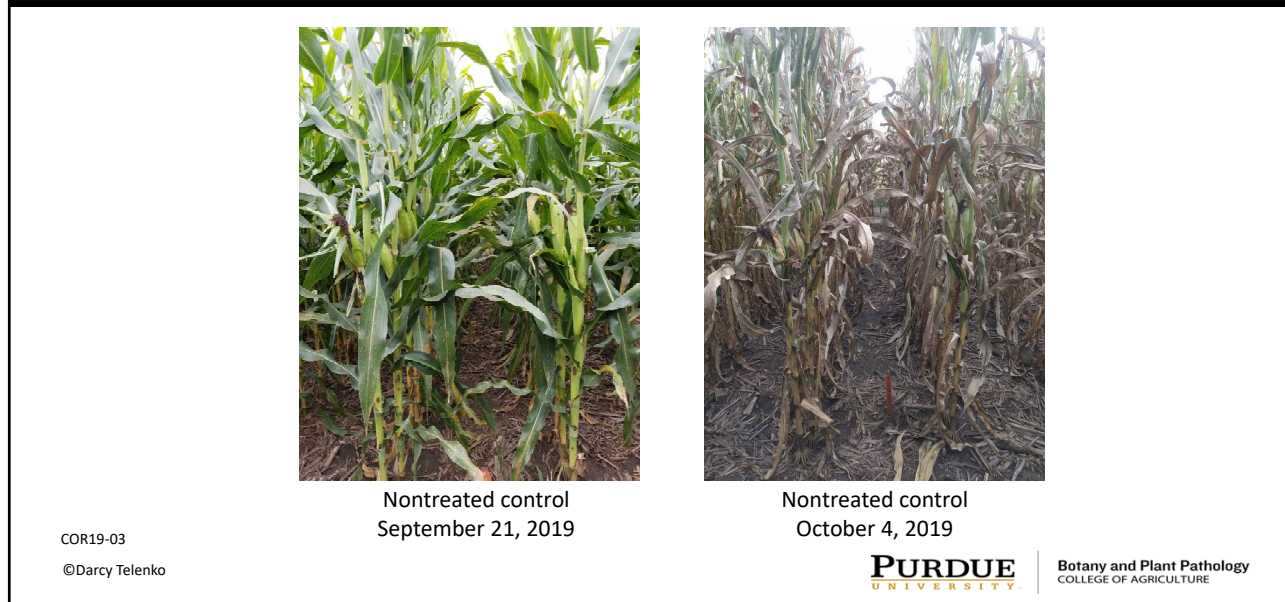
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Necrosis Development in Non-Treated Canopy, Indiana 2019



Tar Spot



Fungicides Labeled/2(EE) in 2019

- Delaro 2(EE)
- Trivapro
- Headline AMP 2 (EE)
- Quilt Xcel 2 (EE)
- Miravis Neo 2(EE)
- Lucento 2(EE)
- Aproach Prima 2(EE)
- Veltyma

- The list is growing
 - Check 2(EE) for your state as they may vary

Fungicide Trials

- Efficacy
- Timing
- Timing x Efficacy
- Tillage x Hybrid x Fungicide



Photo credit: FMC

General Field Trial Information – Indiana 2019

Tar spot trials at Pinney PAC, Porter County

- Randomized complete block, with four replications
- 4-row plots (10-ft wide) by 30-ft long
- Planted on 8 Jun - 'W2585SSRIB'
- Irrigation applied to some plots on weekly basis (1") if rain less than 1" for that week
- Fungicide applications made with Lee self-propelled sprayer
 - 15 gal/A at 40 psi, 10-ft boom with six TJ-VS 8002 nozzels spaced 20-in. apart, at 3.6 mph
- Disease severity rated visually by assessing % area of leaf tissue on at least 5 plants/plot
- Yield from two center rows, adjusted to 15.5% moisture

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Fungicide Efficacy Trials

Fungicides applied at VT/R1 in Various Trials

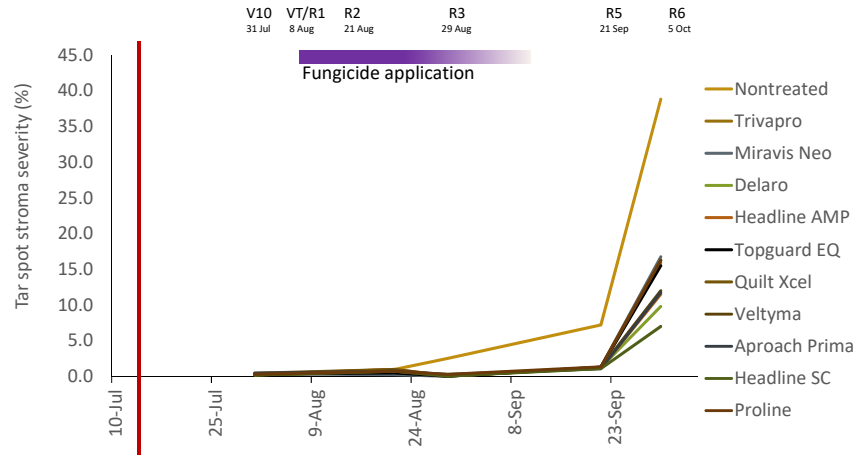
- Aproach Prima
- Delaro
- Headline
- Headline AMP
- Miravis Neo
- Proline
- Quilt Xcel
- Topguard
- Trivapro
- Veltyma
- Lucento
- VJR90-R002
- Brixen
- Fortix
- Dexter Xcel

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Uniform Fungicide Trial for Tar Spot - Trial 1 in Indiana 2019



Trial COR19-03
Location: PPAC
Hybrid: 'W2585SRIB'

13 July - tar spot first detected in Porter Co.

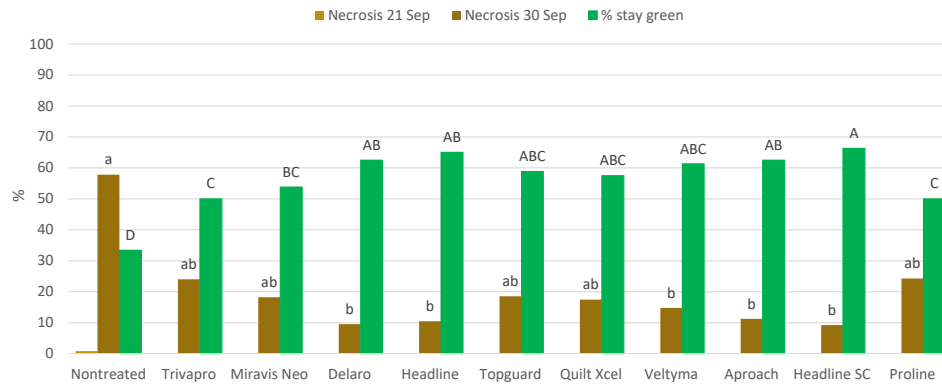
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Uniform Fungicide Trial - Effect on Leaf Necrosis and Stay Green - Trial 1 in Indiana 2019

13 July - tar spot first detected in Porter Co.



Trial COR19-03
Location: PPAC
Hybrid: 'W2585SRIB'

Necrosis $F=3.77$ ($p=0.0024$)
Stay green $F=17.03$ ($p=0.0001$)

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Uniform Fungicide Trials for Tar Spot – Severity on Ear Leaf and Yield - Trial 1 in Indiana 2019

Treatments	Rate	Tar spot (% ear leaf)	Yield (bu/A)
Approach Prima	6.8 fl oz	5.7 bc	209.21
Delaro	12 fl oz	6.1 bc	223.60
Headline	12 fl oz	4.3 c	214.01
Headline AMP	14.4 fl oz	6.0 bc	218.10
Miravis Neo	13.7 fl oz	7.6 bc	215.24
Proline	5.7 fl oz	10.2 bc	206.10
Quilt Xcel	14 fl oz	9.3 bc	214.15
Topguard	7 fl oz	6.8 bc	211.77
Trivapro	13.7 fl oz	7.9 bc	212.24
Veltyma	7 fl oz	6.1 bc	215.38
Nontreated control		23.5 a	202.62

Change in yield over nontreated was 3.5 to 21.0 bu/A

F-Value 19.58
P-Value 0.0001

Trial COR19-03
Location: PPAC
Hybrid: 'W2585SSRIB'

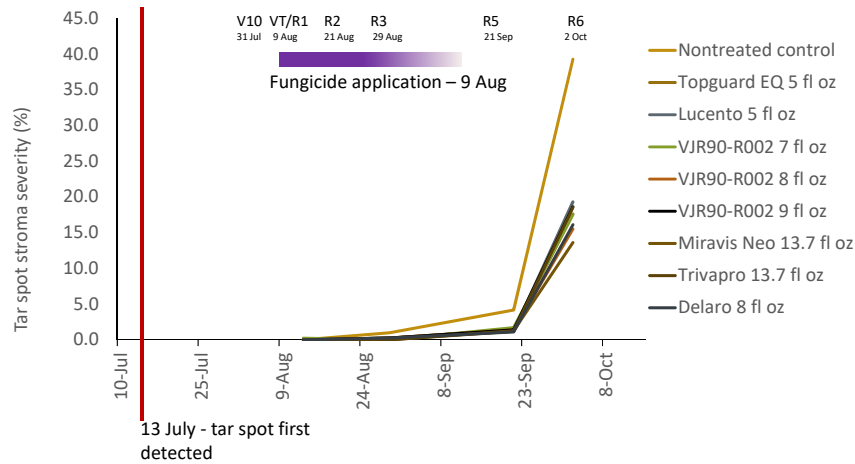
Fungicide applications made at VT/R1. Mean separation Tukey-Kramer P=0.05.

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Fungicide Efficacy on Tar Spot Stroma – Trial 2 in Indiana 2019



Trial COR19-13
Location: PPAC
Hybrid: 'W2585SSRIB'

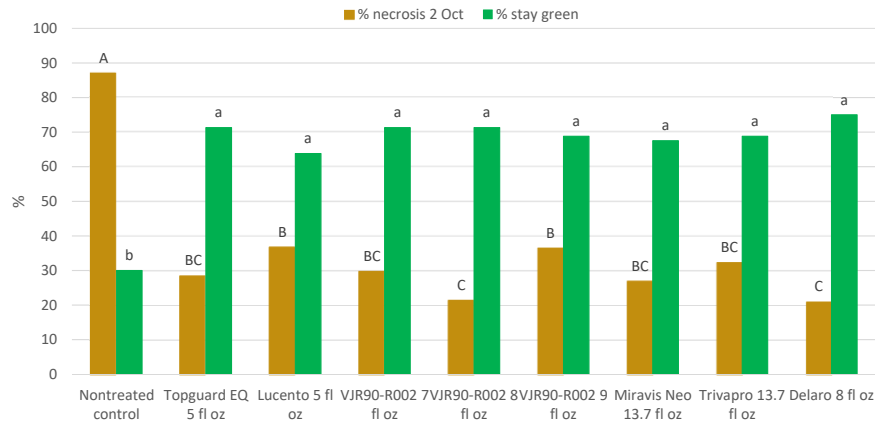
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Fungicide Effect on Leaf Necrosis and Stay Green - Trial 2 in Indiana 2019

13 July - tar spot first detected in Porter Co.



Trial COR19-13
Location: PPAC
Hybrid: 'W2585SSRIB'

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Fungicide Efficacy for Tar Spot Ear Leaf Severity and Yield – Trial 2 in Indiana

Treatments	Rate	Tar spot (% ear leaf) 2 Oct	Lodging (%) 2 Oct	Yield (bu/A) 25 Oct
Topguard EQ	5 fl oz	17.6 b	2.5 b	214.62 a
Lucento	5 fl oz	19.3 b	2.5 b	217.59 a
VJR90-R002	7 fl oz	17.5 b	0.0 b	215.87 a
VJR90-R002	8 fl oz	15.5 b	2.5 b	216.12 a
VJR90-R002	9 fl oz	18.6 b	2.5 b	217.89 a
Miravis Neo	13.7 fl oz	13.6 b	7.5 b	217.37 a
Trivapro	13.7 fl oz	18.5 b	2.5 b	216.96 a
Delaro	8 fl oz	16.1 b	5.0 b	217.45 a
Nontreated control		39.3 a	17.5 a	197.26 b
	F-Value	0.0001	0.0111	0.0081
	P-Value	7.86	8.40	10.25

Change in yield over nontreated was 17.4 to 20.6 bu/A

Trial COR19-13
Location: PPAC
Hybrid: 'W2585SSRIB'

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Fungicide applications made at VT/R1 on 9 Aug. Mean separation Protected LSD P=0.05.



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Lodging Risk – Pinney PAC Trial



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Lodging – St. Joseph County 2019

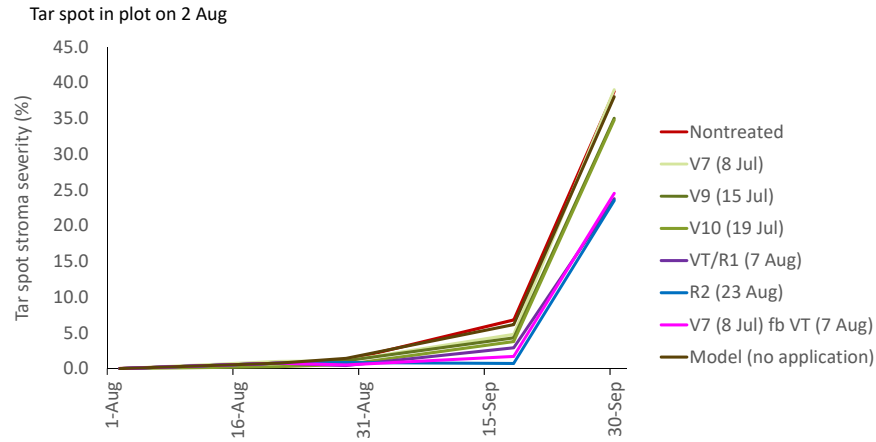


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Fungicide Timing on Tar Spot, Indiana 2019



Trial COR19-05
 Location: PPAC
 Hybrid: 'W2585SRIB'
 Fungicide: Trivapro 13.7 fl oz/A

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Fungicide Timing Effect on Tar Spot and Corn Yield, Indiana 2019

Treatments	Rate		Tar spot (% ear leaf) 30 Sep	Stay green (%) 30 Sep	Yield (bu/A) 28 Oct
Trivapro	13.7 fl oz	V7	39.00 a	41.3cd	182.33 c
Trivapro	13.7 fl oz	V9	35.00 a	43.8cd	188.28 bc
Trivapro	13.7 fl oz	V10	34.75 a	50.0bc	191.63 abc
Trivapro	13.7 fl oz	VT	23.75 b	55.0ab	202.58 ab
Trivapro	13.7 fl oz	R2	23.50 b	63.8a	205.23 a
Trivapro	13.7 fl oz	V7 fb VT	24.50 b	57.5ab	202.48 ab
Trivapro—not applied	13.7 fl oz	Model Based	38.00 a	37.5d	181.63 c
Nontreated control			38.75 a	38.8d	181.85 c
	P-Value		0.0001	0.0001	0.0051
	LSD		6.62	9.34	14.56

Fungicides applied on V7 (8 Jul), V9 (15 Jul), V10 (19 Jul), VT (7 Aug), and R2 (23 Aug)

Trial COR19-05
 Location: PPAC
 Hybrid: 'W2585SRIB'

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Fungicide Timing x Efficacy – Indiana 2019

Fungicide treatment

- V5 – 3 Jul
- R1 – 9 Aug
- V5 fb R1

- Delaro 8 fl oz
- Trivapro 13.7 fl oz
- Miravis Neo 13.7 fl oz

Trial COR19-15
Location: PPAC
Hybrid: 'W2585SSRIB'

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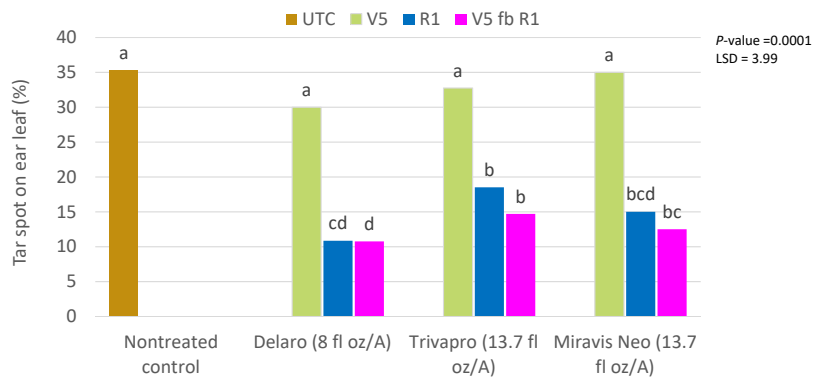
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Fungicide Timing on Tar Spot, Indiana 2019

13 July - tar spot first
detected on in Porter Co.

2 Oct 2019



Trial COR19-15
Location: PPAC
Hybrid: 'W2585SSRIB'

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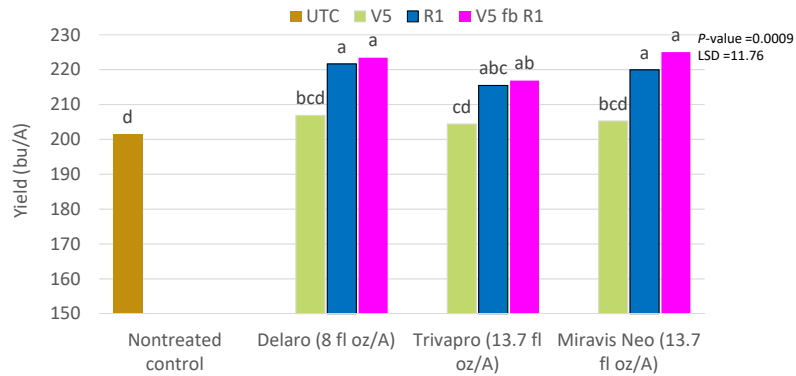
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Fungicide Timing on Corn Yield, Indiana 2019

13 July - tar spot first detected on in Porter Co.

28 Oct 2019



Trial COR19-15
Location: PPAC
Hybrid: 'W2585SSRIB'

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Tillage x Variety x Fungicide – Indiana 2019

Treatment

- No-till
- Tillage – chisel plowed 14 Nov and cultivated on 6 June
- W2585SSRIB – susceptible
- DLS RPM-4329AM – moderately susceptible
- P0589AMXT – moderately resistant
- Nontreated control
- Trivapro 13.7 fl oz/A at VT/R1 on 9 Aug

Trial COR19-07
Location: PPAC

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Tillage Effect on Tar Spot and Corn Yield, 2019

Treatments	Tar spot (% ear leaf) 2 Oct	Stay green (%) 2 Oct	Lodge (%) 2 Oct	Yield (bu/A) 28 Oct
No-till	14.81	54.79	1.25	203.72
Tillage	11.66	59.38	0.88	202.10
P-Value	0.3790	0.4388	0.5225	0.7455

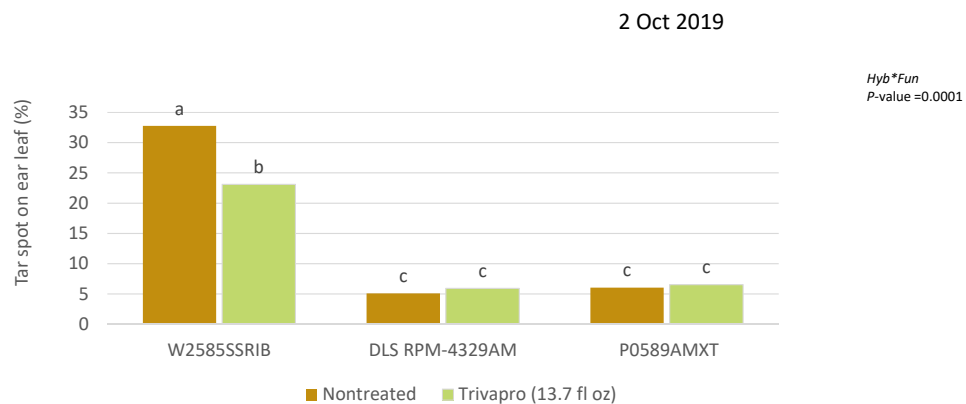
Trial COR19-07
Location: PPAC

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Hybrid x Fungicide on Tar Spot, Indiana 2019



Trial COR19-07
Location: PPAC
13 July - tar spot first
detected on in Porter Co.

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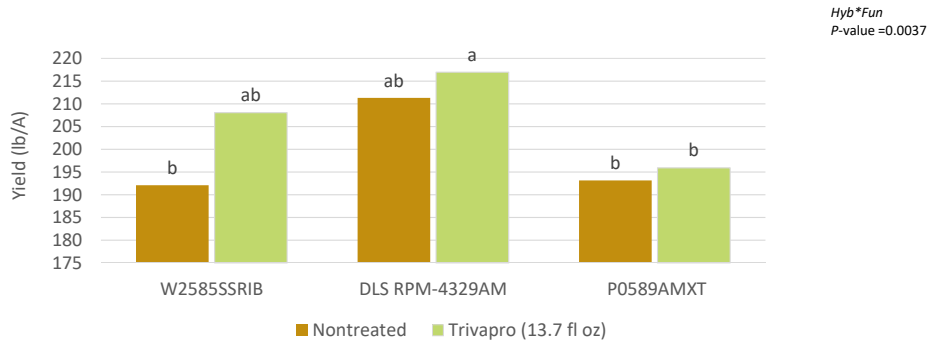
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Hybrid x Fungicide on Corn Yield, Indiana 2019

13 July - tar spot first
detected on in Porter Co.

28 Oct 2019



Trial COR19-07
Location: PPAC

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Hybrid x Fungicide on Tar Spot and Corn Yield, 2019

Treatments	Tar spot (% ear leaf) 2 Oct	Stay green (%) 2 Oct	Lodge (%) 2 Oct	Yield (bu/A) 28 Oct
W2585SSRIB, Non treated	32.75 a	26.88 d	4.38 a	192.10 b
W2585SSRIB, Trivapro	23.10 b	40.63 c	1.25 b	208.04 ab
DLS RPM-4329AM, Nontreated	5.08 c	65.00 ab	0.25 b	211.30 ab
DLS RPM-4329AM, Trivapro	5.93 c	76.25 a	0.13 b	216.96 a
P0589AMXT, Nontreated	6.03 c	60.00 b	0.25 b	193.13 b
P0589AMXT, Trivapro	6.53 c	73.75 a	0.13 b	195.93 ab
P-Value	0.0001	0.0001	0.0001	0.0037

Trial COR19-07
Location: PPAC

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Management Practices for Tar Spot as Suggested in CPN-2012-W

- **Avoid highly susceptible hybrids**
- **Consider fungicides**
 - Mixed mode of action
 - **Timing very important**
 - Application will need to occur close to the onset of the epidemic
- **Manage irrigation**
- **Rotate to other crops**
- **Manage residue**
- **Scout**



Take Home

- Tar spot is here and likely to continue to spread
- Likely to be an episodic disease similar to white mold or Fusarium Head Blight
- Be aware of the disease, and manage accordingly
- Scout your fields and pay attention to weather and reports to determine if within season management is required



Disease Diagnosis and Resources

- Monitor fields in 2020 for disease
- **If disease is suspected, confirm disease by sending a sample to diagnostic lab**
- **Keep an eye out for future in season updates**
 - Purdue Pest&Crop newsletter
 - Follow me on Twitter @DTelenko
 - <https://extension.purdue.edu/fieldcroppathology/>



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- Tar Spot Working Group

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QUESTIONS?

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