

SUSTAINABLE TURFGRASS MANAGEMENT IN ASIA 2026



Digging into the Roots of Ectotrophic Root-Infecting (ERI) Fungal Diseases

March. 11th, 2026

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Outline

- Introduction to ERI fungal diseases
- Predisposing factors for ERI diseases
- How to manage ERI fungal diseases – chemical control
- How to manage ERI fungal diseases – cultural practices
- A new tool



ERI Disease Symptoms Are Often Confused With Other Root Diseases

Pythium Root Rot on Bermudagrass putting green



Photos by Dr. Jim Kerns, North Carolina State University

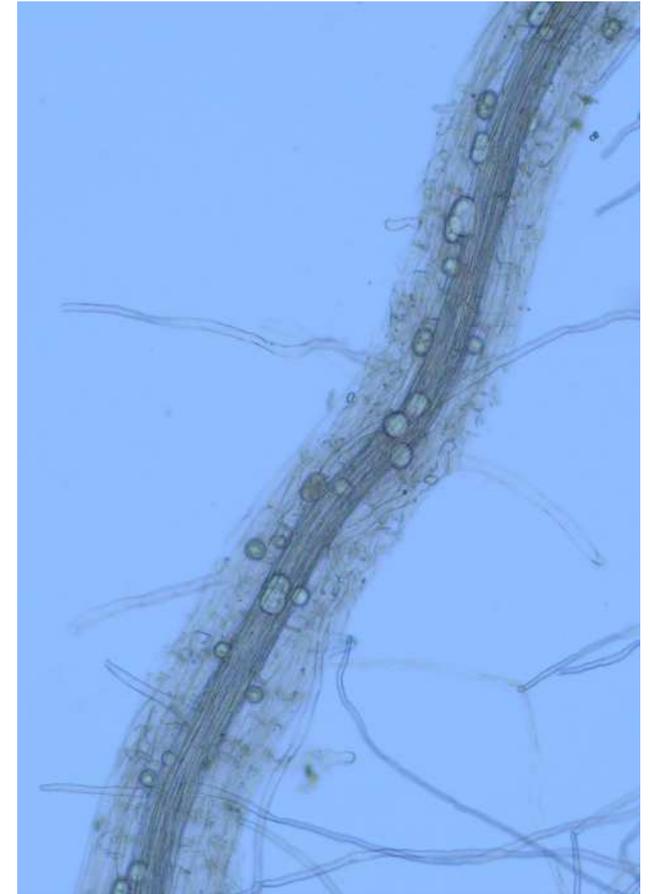
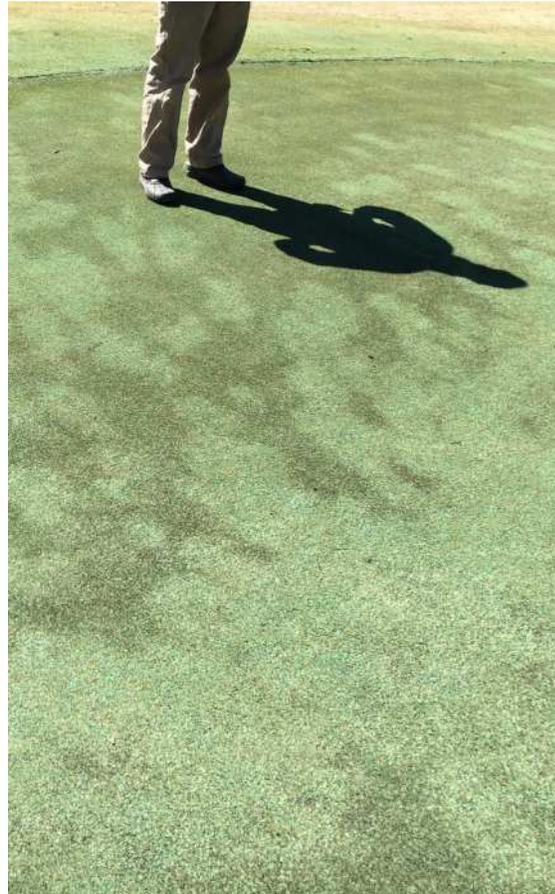
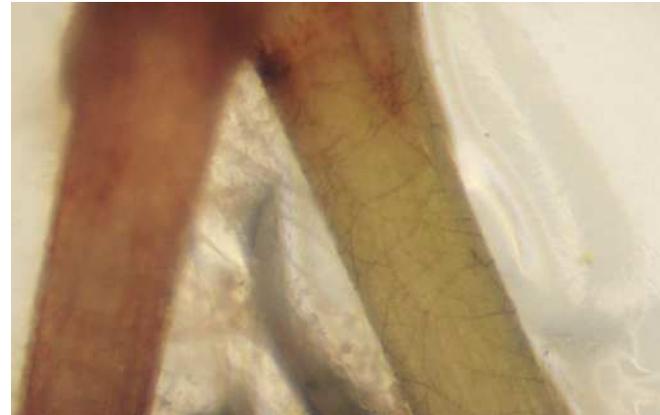


Photo by Dr. Lee Miller, Purdue University

Common Ectotrophic Root-Infecting (ERI) Fungal Diseases

- Cool-season grasses:
Summer Patch
Take-All Patch
Necrotic Ring Spot
Bentgrass Dead Spot
- Warm-season grasses:
Take-All Root Rot
(Bermudagrass decline)
Spring Dead Spot
Fairway Patch



โรครากเน่าจากเชื้อรากลุ่มเอ็กโตโทรฟิก



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Summer patch at the White House

A look back at a historic example of turf disease on the White House lawn.

August 2024 | Mike Fidanza 

Filed to: [Washington DC](#), [summer patch](#), [Disease](#)

Today's turfgrass pathologist has extensive training in molecular biology, genetics, genomics and more. However, back in the day, plant pathologists had to rely on the microscope to intensively study the physical characteristics of fungi. Most turf diseases are caused by fungi, and the fungal pathogen that causes summer patch was once the topic of fierce debate.

In the 1950s and 1960s, this "patch" disease was called fusarium blight because many *Fusarium* sp. commonly inhabit soils. The other name was SOB (summer obliteration of bluegrasses). From the late 1960s, there's a famous photo of President Lyndon Johnson speaking on the White House lawn. No one can recall the speech, but the distinct "frog-eye" pattern of necrotic Kentucky bluegrass meant one thing: summer patch. Kentucky bluegrass lawns and annual bluegrass putting greens are susceptible to this severe root disease, but no one knew what pathogen caused these circular dead patches of turf that appeared in the summer.

The Evolution of Our Understanding Towards ERI Diseases

Phase of one-pathogen-one-disease

- *Fusarium* blight (Dr. Richard Smiley)
- *Phialophora* (Drs. Peter Landschoot & Noel Jackson)
- *Gaeumannomyces* (Dr. Peter Landschoot)
- *Magnaporthe* (Dr. John Walker)
- *Magnaporthe poae* (Dr. Peter Landschoot)
- *Magnaportheopsis poae* (Dr. Ning Zhang)

Phase of disease complex



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COLD CASE FILES

**DNA
SPEAKS™**

Common Symptoms of ERI Diseases



Dr. Lee Miller, Purdue University



Chase Skrubis, Cornell University



Dr. Lee Miller, Purdue University



Jason Osterhoudt, Metuchen Golf and Country Club



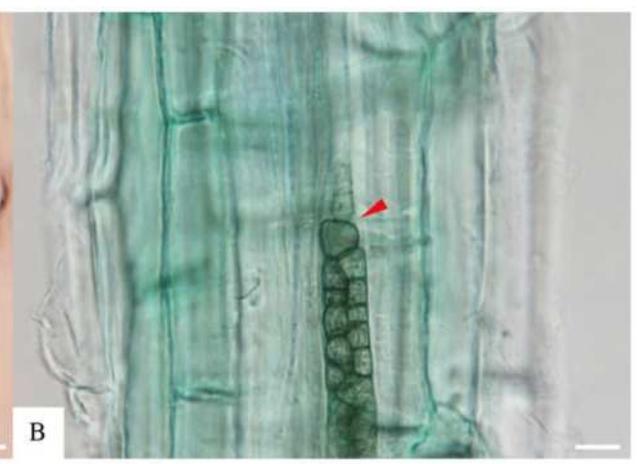
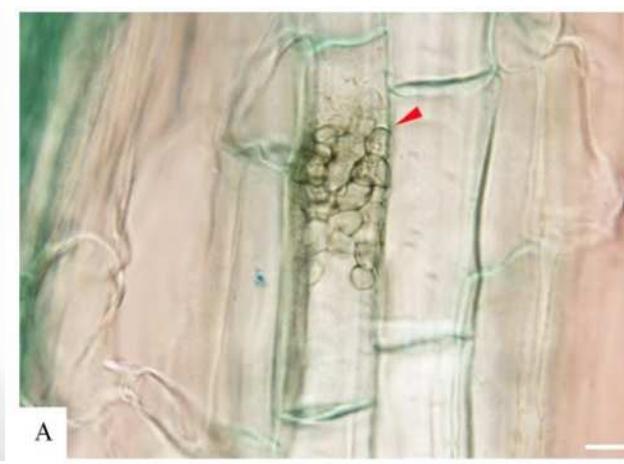
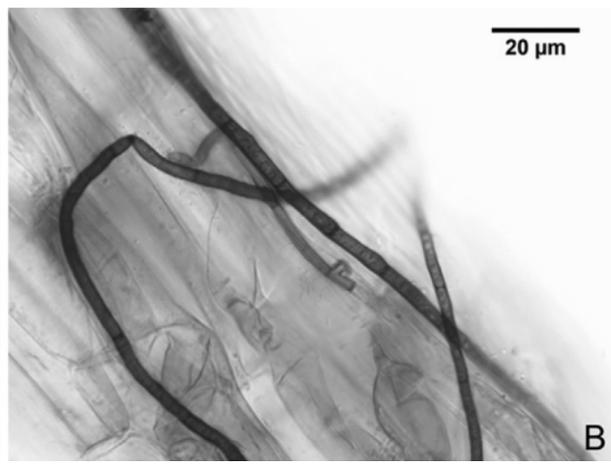
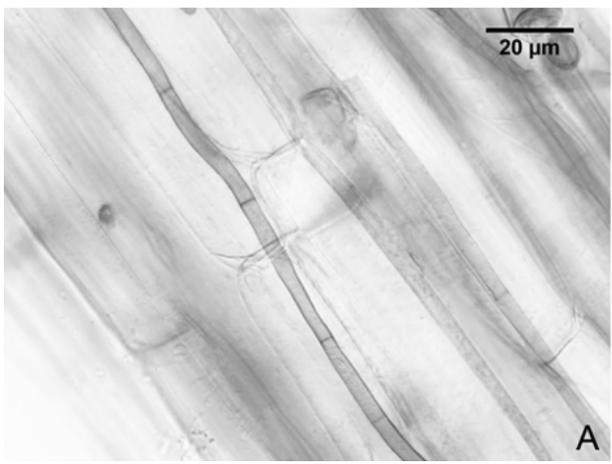
Kyle Genova, Rutgers University

Common Symptoms of ERI Diseases

Take-All Root Rot on Bermudagrass putting green



Photos by Dr. Jim Kerns, North Carolina State University



Luo et al. 2015

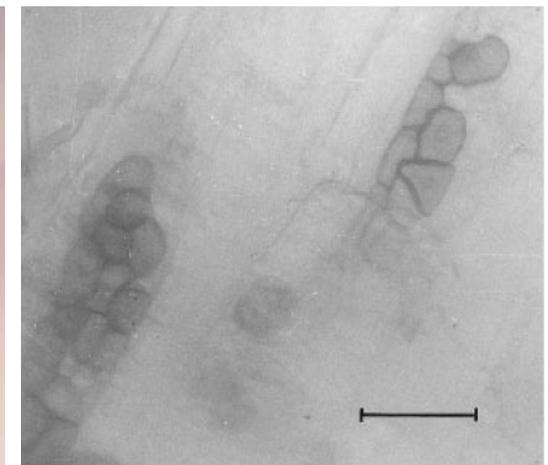
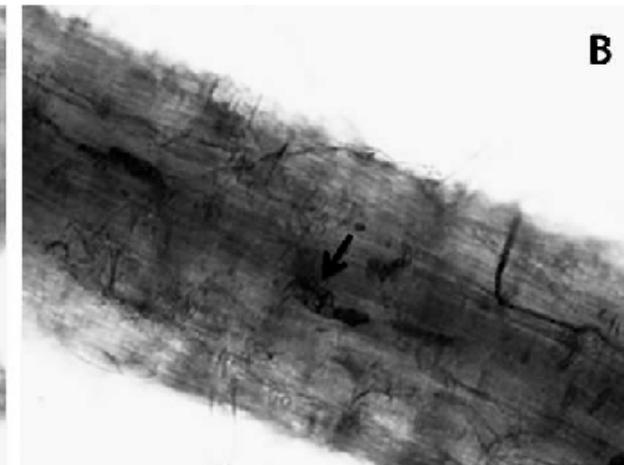
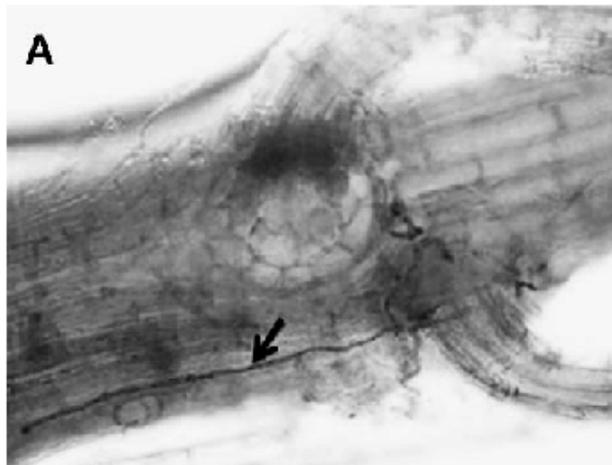
Han et al. 2016



Chou, Rutgers University

Chou, Rutgers University

Martinez, University of Georgia



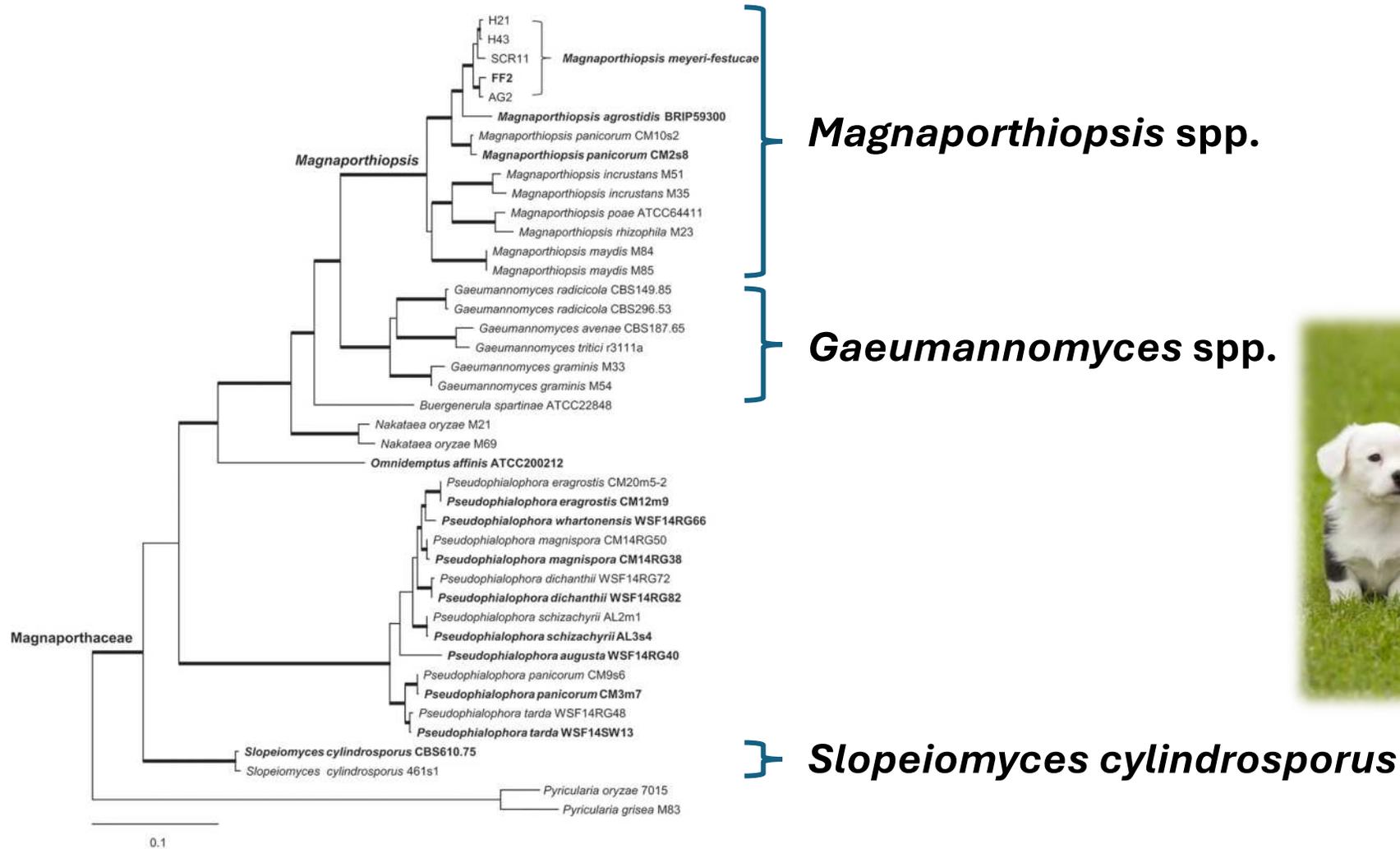
Zhao et al. 2012

Chou, Rutgers University

Ulrich et al. 2000



Magnaporthaceae family





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How Do We Confirm The Criminals?



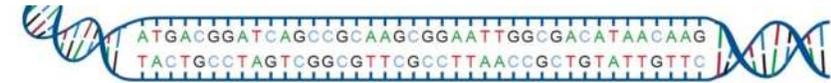
Pathogen isolation

Select 10-20 infected roots

Incubation in varied temperatures

25°C

30°C



Identification



CBA-1



CBA-1



CBA-4



CBA-4



CBA-3



CBA-3



CBA-2



CBA-2



CBA-5



CBA-5



KB-1



KB-1



Control



Control



Creeping bentgrass

Annual bluegrass
Slopeiomyces cylindrosporus

Kentucky bluegrass



New Species of Causal Agents Keep Emerging

DISEASE NOTE

First Report of *Phialocephala bamuru* Causing Root Rot on Hard Fescue (*Festuca brevipila*) in the United States

Patrick Fardella, Glen Groben, Pingyuan Zhang, Kyle Genova, Ning Zhang, James Murphy, Bruce Clarke, and Ming-Yi Chou

Fairway patch – a serious emerging disease of couch (syn. bermudagrass) [*Cynodon dactylon*] and kikuyu (*Pennisetum clandestinum*) turf in Australia caused by *Phialocephala bamuru* P.T.W. Wong & C. Dong sp. nov.

Original Paper | Published: 26 August 2015

Volume 44, pages 545–555, (2015) Cite this article

P. T. W. Wong, C. Dong, P. M. Martin & P. J. Sharp

Magnaporthiopsis cynodontis, a novel turfgrass pathogen with widespread distribution in the United States

Phillip L. Vines, Federico G. Hoffmann, Florencia Meyer, Thomas W. Allen, Jing Luo, Ning Zhang & ...show all

Pages 52-63 | Received 01 Feb 2019, Accepted 02 Oct 2019, Published online: 17 Dec 2019

Magnaporthiopsis meyeri-festuciae, sp. nov., associated with a summer patch-like disease of fine fescue turfgrasses

Jing Luo, Phillip L. Vines, Austin Grimshaw, Lindsey Hoffman, Emily Walsh, Stacy A. Bonos, ...show all

Pages 780-789 | Received 30 Jun 2017, Accepted 31 Oct 2017, Accepted author version posted online: 13 Nov 2017, Published online: 02 Jan 2018



Magnaporthiopsis species associated with patch diseases of turfgrasses in Australia

Wong PTW¹, Tan YP^{2,3}, Weese TL² and Shivas RG^{2,3,*}

Gaeumannomyces nanograminis, sp. nov., a hyphopodiate fungus identified from diseased roots of ultradwarf bermudagrass in the United States

Phillip L. Vines, Federico G. Hoffmann, Florencia Meyer, Thomas W. Allen & Maria Tomaso-Peterson

Pages 938-948 | Received 30 Oct 2020, Accepted 29 Mar 2021, Published online: 16 Jun 2021

The evolution of our understanding towards root diseases

Phase of one-pathogen-one-disease

- *Fusarium* blight (Dr. Richard Smiley)
- *Phialophora* (Drs. Peter Landschoot & Noel Jackson)
- *Gaeumannomyces* (Dr. Peter Landschoot)
- *Magnaporthe* (Dr. John Walker)
- *Magnaporthe poae* (Dr. Peter Landschoot)
- *Magnaportheopsis poae* (Dr. Ning Zhang)

Phase of disease complex



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Take-All Root Rot Pathogens on Bermudagrass



Photo by Dr. Jim Kerns, North Carolina State University

Gaeumannomyces graminis, *Gaeumannomyces* sp., *G. graminicola*, *Candidacolonium cynodontis*, and *Magnaporthiopsis cynodontis*



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Take-All Root Rot Pathogens on St. Augustinegrass



Photo by Dr. Young-Ki Jo, Texas A&M University

Gaeumannomyces graminis, *G. arxii*, *G. californicus*, *G. floridanus*, and *G. graminicola*

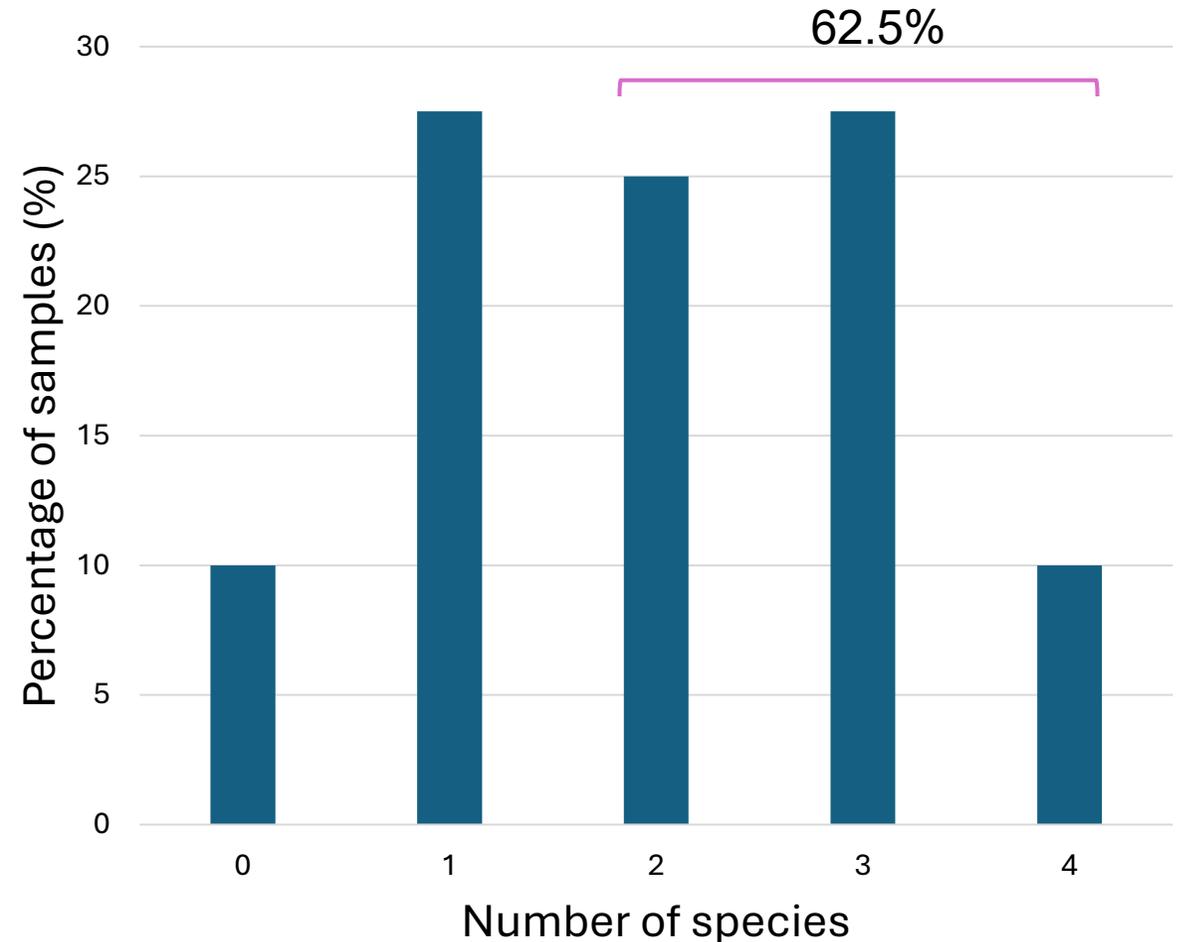
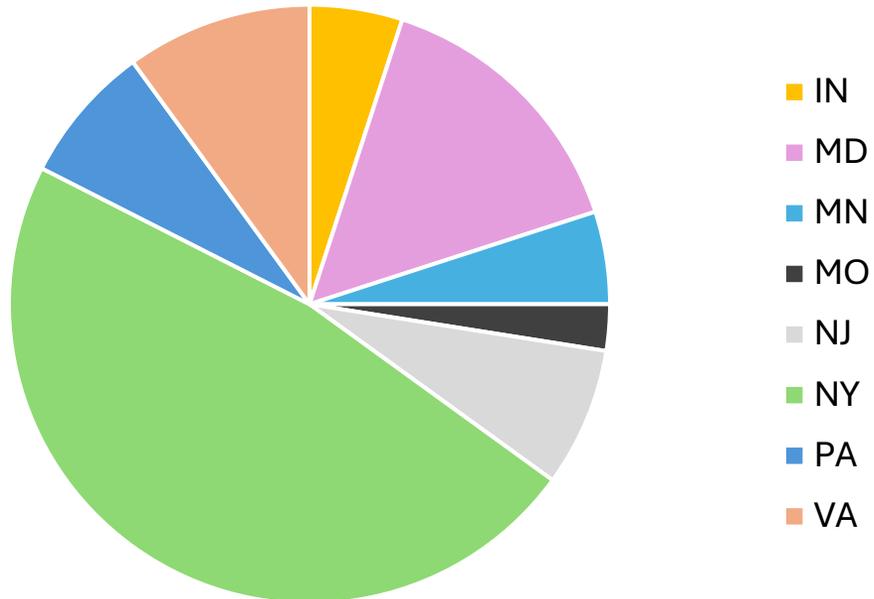
Summer Patch and Take-all Patch Associated Pathogens



Magnaporthiopsis poae, *M. meyeri-festucaae*, *M. incrustans*, *M. cynodontis*, *M. yugambeh*, *Slopeiomyces cylindrosporus*, and *Gaeumannomyces avenae*

40 samples received from 8 states for high-throughput diagnosis

การหาลำดับนิวคลีโอไทด์สมรรถนะสูง
Samples for HTS root diagnosis



Knowledge Gaps in ERI Fungal Pathogens

Species	CB	KB	AB	FF	BG	KG	SA	ZG	Others	Weak	Moderate	Aggressive
<i>Magnaporthiopsis cynodontis</i>		Aggressive			Moderate					P.L. Vines <i>et al.</i> , 2019 and 2020		
<i>Magnaporthiopsis meyeri-festucaae</i>		Moderate		Moderate						P.L. Vines <i>et al.</i> , 2020		
<i>Magnaporthiopsis poae</i>	Weak	Moderate		Aggressive						J. Hu <i>et al.</i> , 2017; P.L. Vines <i>et al.</i> , 2020; Kemp, M. L. (1991)		
<i>Magnaporthiopsis yugambeh</i>			Weak							P.T.W. Wong <i>et al.</i> , 2020		
<i>Magnaporthiopsis gadigal</i>						Moderate				P.T.W. Wong <i>et al.</i> , 2020		
<i>Magnaporthiopsis gumbaynggirr</i>						Moderate				P.T.W. Wong <i>et al.</i> , 2020		
<i>Gaeumannomyces avenae</i>	Moderate								Moderate	E.M. Turner, 1940		
<i>Gaeumannomyces graminicola</i>					Moderate					C.M. Stephens <i>et al.</i> , 2021		
<i>Gaeumannomyces graminis</i>					Weak		Moderate			C.M. Stephens <i>et al.</i> , 2021; L. E. Datnoff <i>et al.</i> , 2007		
<i>Gaeumannomyces incrustans</i>		Moderate	Moderate	Aggressive				Weak		P.J. Landschoot and N. Jackson, 1989; E.S. Bucher & H.T. Wilkinson, 2007		
<i>Gaeumannomyces nanograminis</i>					Weak					P.L. Vines <i>et al.</i> , 2021		
<i>Candidacolonium cynodontis</i>					Moderate					C.M. Stephens <i>et al.</i> , 2021		
<i>Candidacolonium agrostis</i>	Moderate									J. Geng <i>et al.</i> , 2023		
<i>Slopeiomyces cylindrosporus</i>	Moderate	Aggressive	Weak							Chou Lab; Jordan Lab		

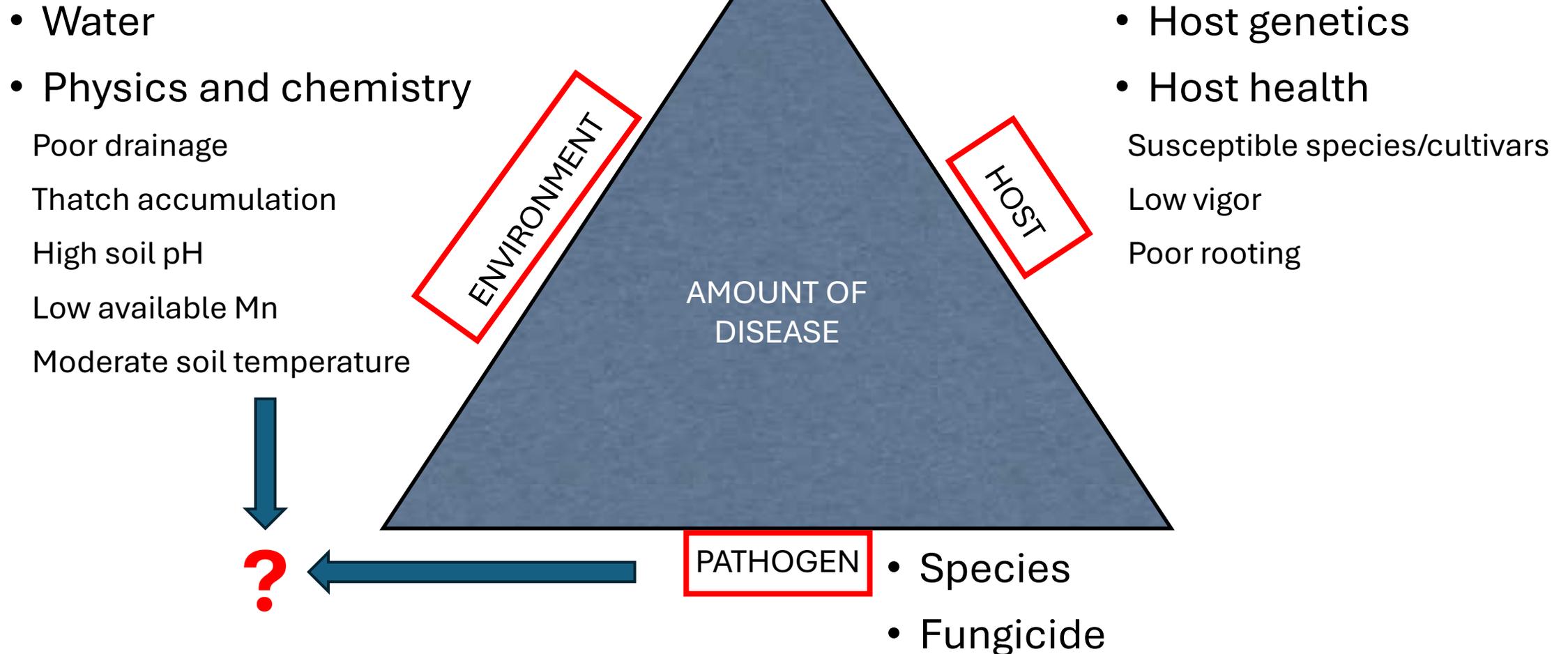
CB=Creeping bentgrass, KB= Kentucky bluegrass, AB= Annual bluegrass, FF= Fine fescues, BG= bermudagrass, KG= Kikuyu grass, SA= St. Augustine grass, ZG= Zoysia grass

Outline

- Introduction to ERI fungal diseases
- Predisposing factors for ERI diseases
- How to manage ERI fungal diseases – chemical control
- How to manage ERI fungal diseases – cultural practices
- A new tool



Predisposing Factors for ERI Fungal Diseases



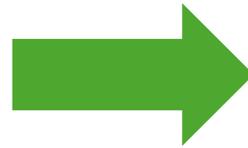
Outline

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Timing is critical

- Fungicide application needs to sync with pathogen activity
- Pathogen \neq Disease

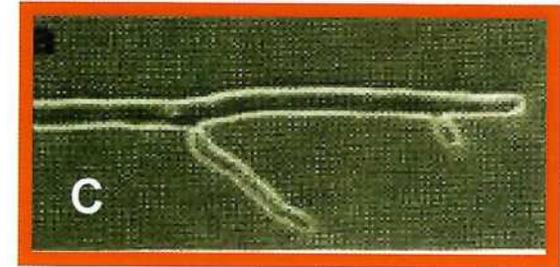
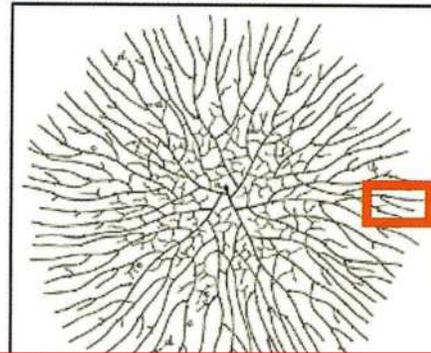
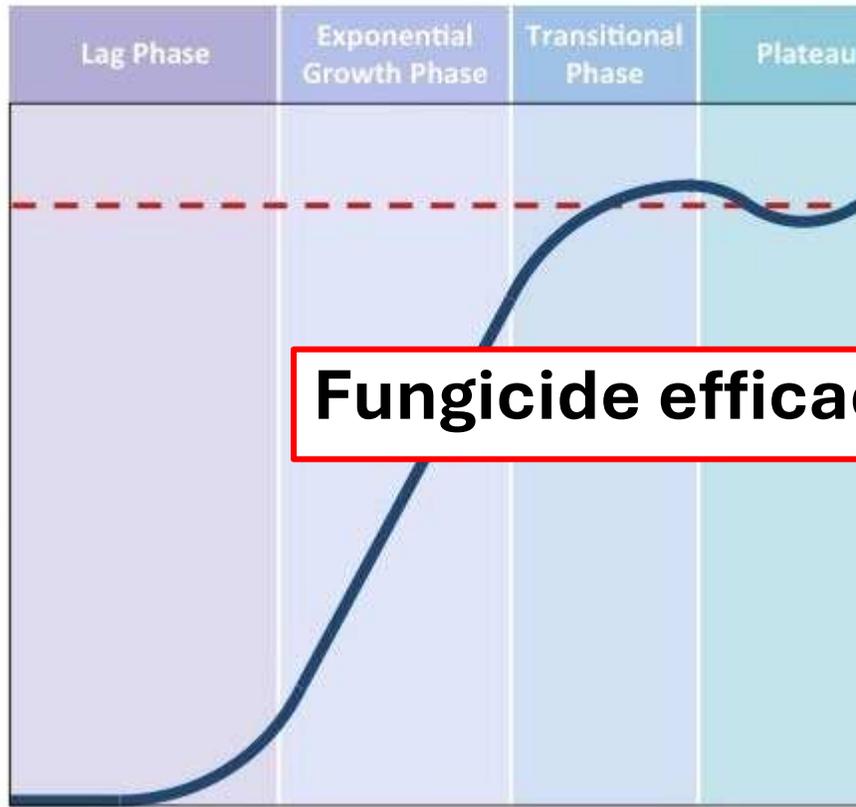




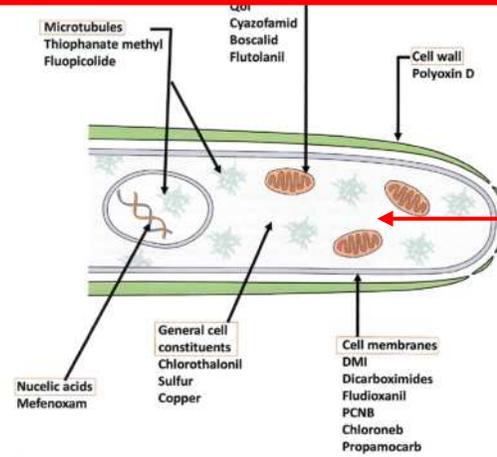
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Soil Temperature / Application Timing is Critical

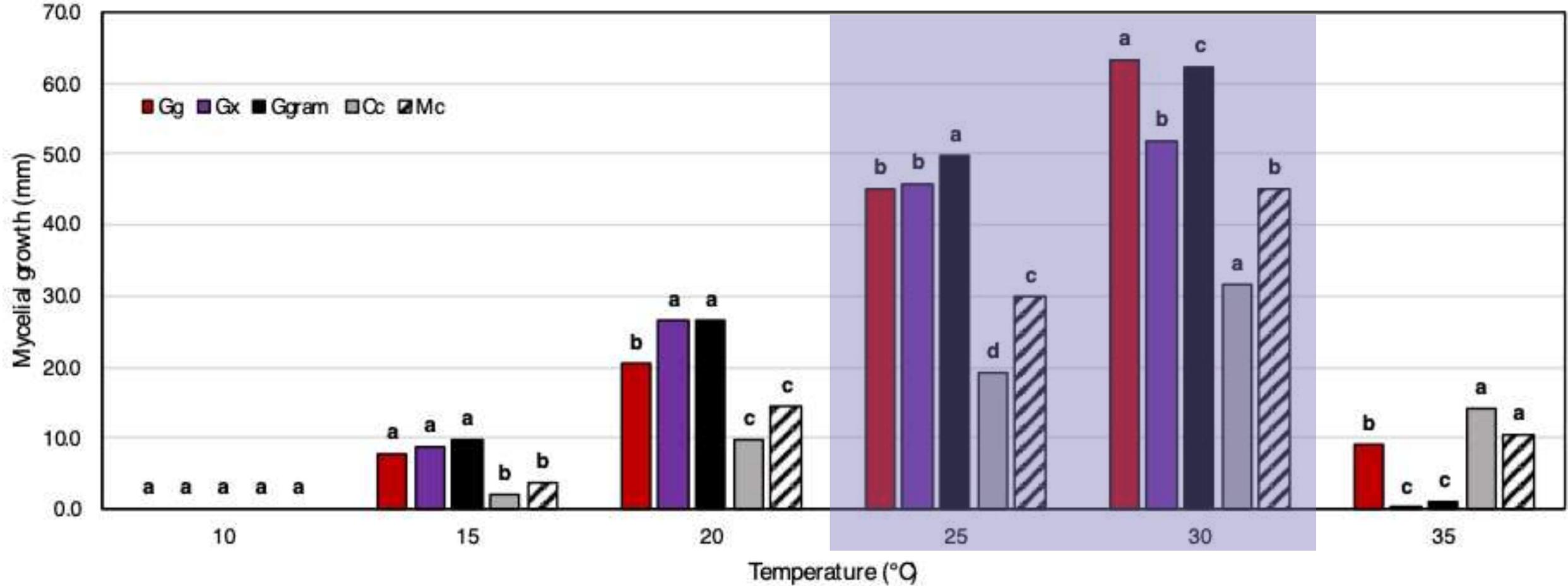


Fungicide efficacy = Fungal activity = Timing



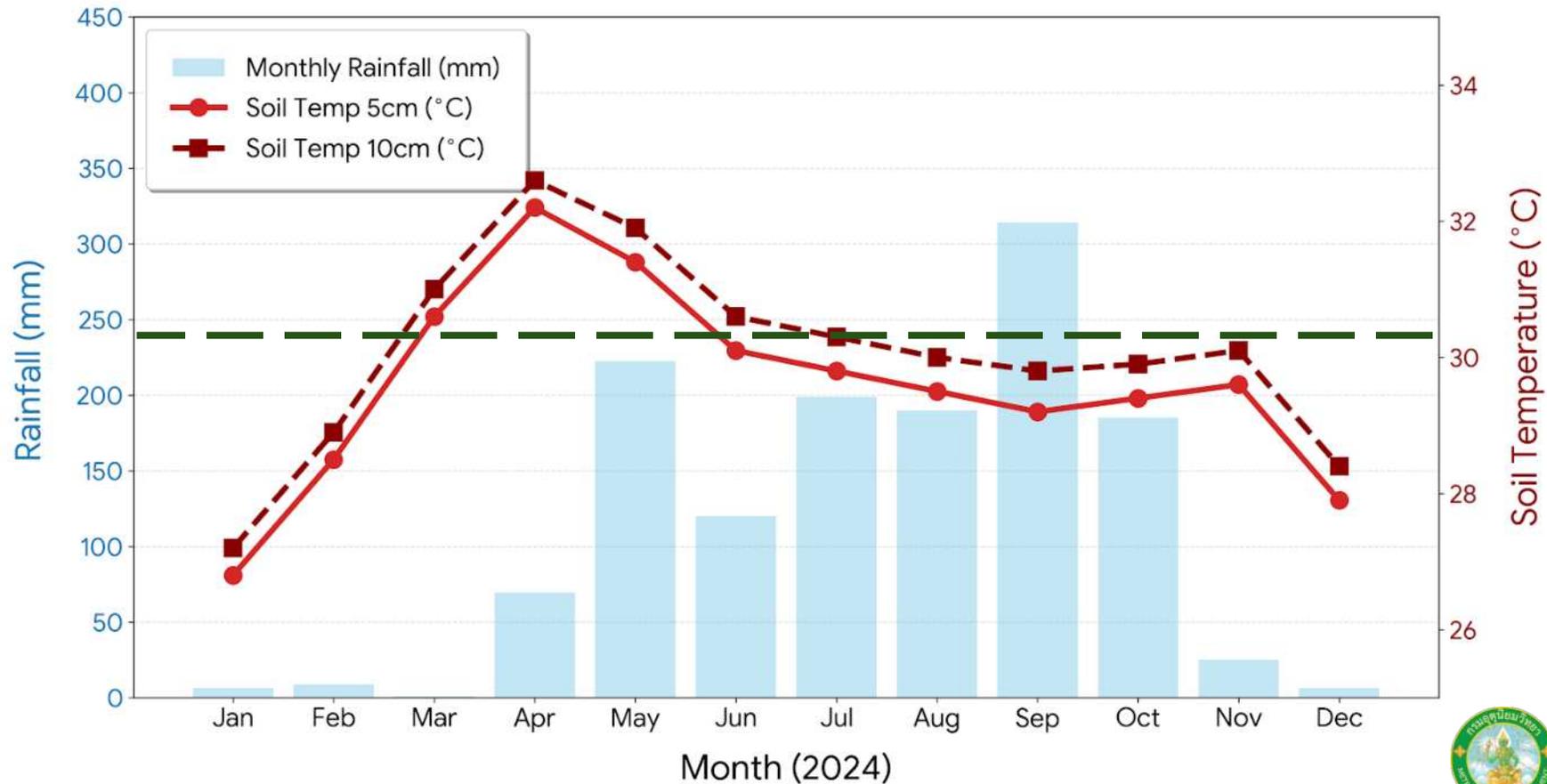
Fungicides

Does pathogen species matter for warm-season grass?

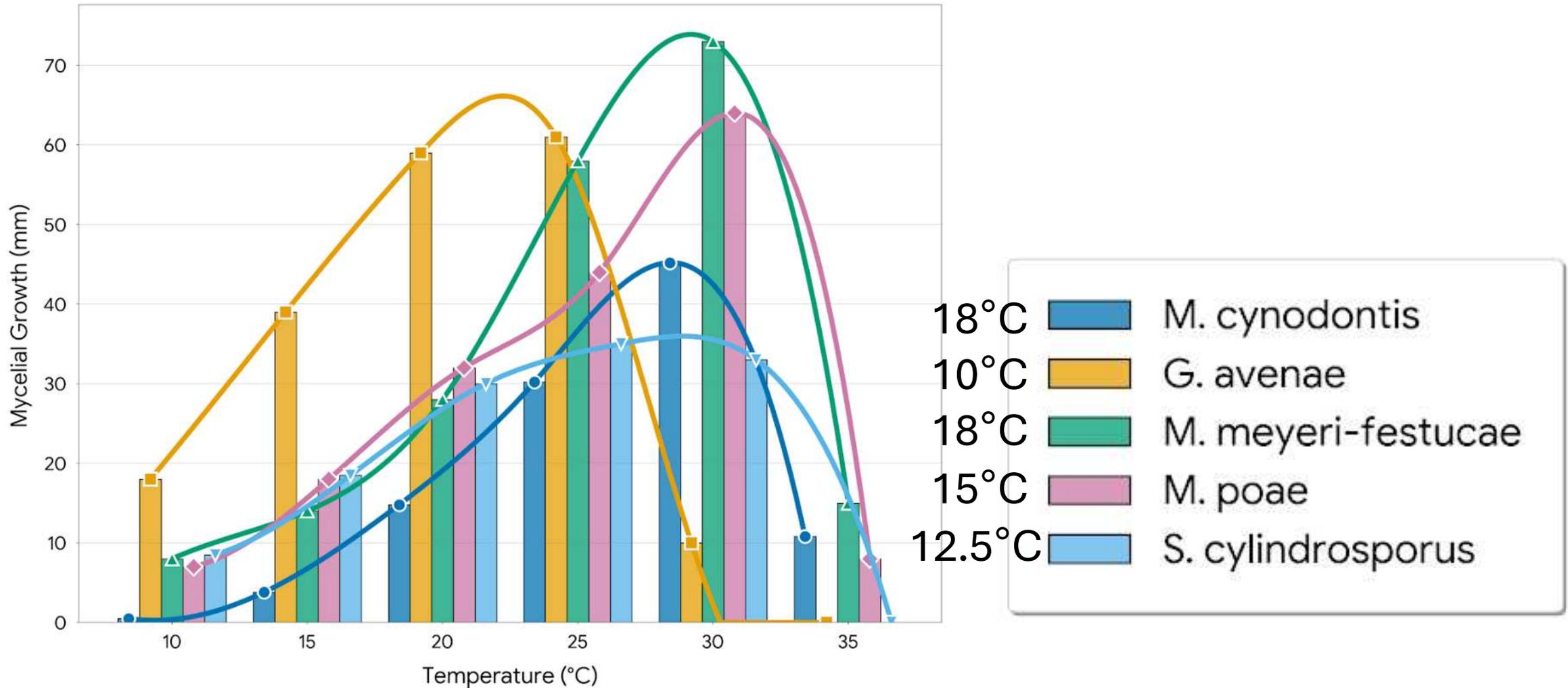


Does pathogen species matter for warm-season grass?

2024 Monthly Rainfall & Soil Temperature Profile
Central Region (Bangkok), Thailand

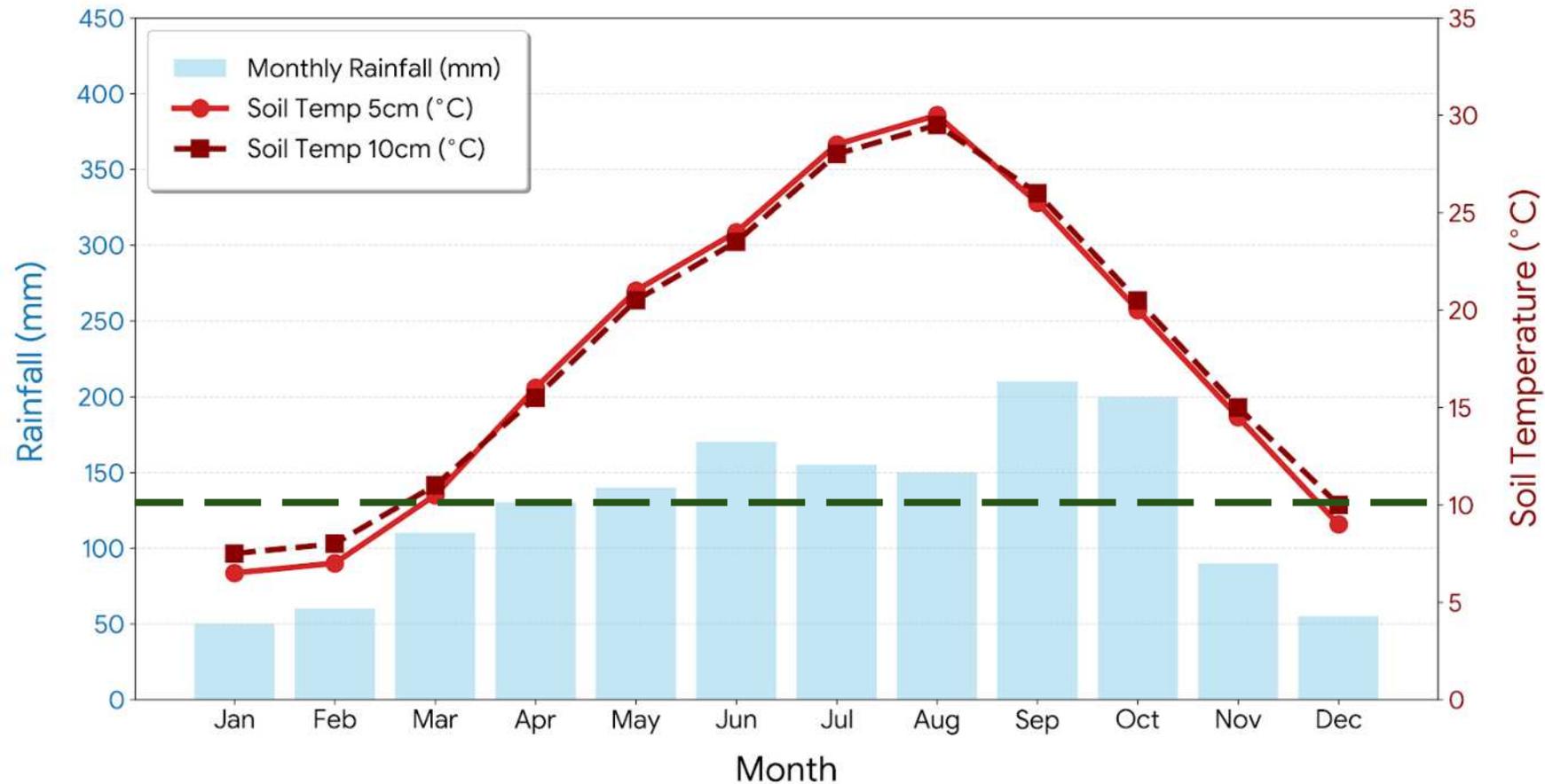


Does pathogen species matter for cool-season grass?



Does pathogen species matter for cool-season grass?

Monthly Rainfall & Soil Temperature Profile
Tokyo, Japan





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Monitoring Soil Temperature is Critical



กรมอุตุนิยมวิทยา
Thai Meteorological Department

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ลักษณะอากาศรายวันเพื่อการเกษตร

All

แสดง

แบ่งปัน

พิมพ์เอกสาร

วัน (ประเทศไทย)	ความชื้นสัมพัทธ์เฉลี่ย (%)	ปริมาณฝนเฉลี่ย (มม.)	อุณหภูมิดินเฉลี่ย (°C)						เวลาที่มิแสงแดด (ชม.)	วันรับ (50 ชม.)
			ที่ 0 ชม.	ที่ 5 ชม.	ที่ 10 ชม.	ที่ 20 ชม.	ที่ 50 ชม.	ที่ 100 ชม.		
เชิงราย สกษ.										
10 ก.พ. 2569	89.0	0.0	22.35	23.30	24.05	25.05	23.90	24.20	0.0	0.00
9 ก.พ. 2569	74.5	0.0	25.33	25.09	24.88	25.53	23.80	24.06	0.0	0.00
8 ก.พ. 2569	73.4	0.0	24.55	24.55	23.98	24.50	23.38	23.71	0.0	0.00
7 ก.พ. 2569	72.5	0.0	24.43	24.34	23.73	23.93	23.26	23.30	0.0	0.00
6 ก.พ. 2569	70.4	0.0	24.05	24.23	23.63	23.58	23.13	23.00	0.0	0.00
5 ก.พ. 2569	71.4	0.0	24.33	24.14	23.51	23.74	22.96	22.89	0.0	0.00
4 ก.พ. 2569	70.4	0.0	24.29	24.09	23.13	23.25	22.96	23.03	0.0	0.00



กรมอุตุนิยมวิทยา
Thai Meteorological Department

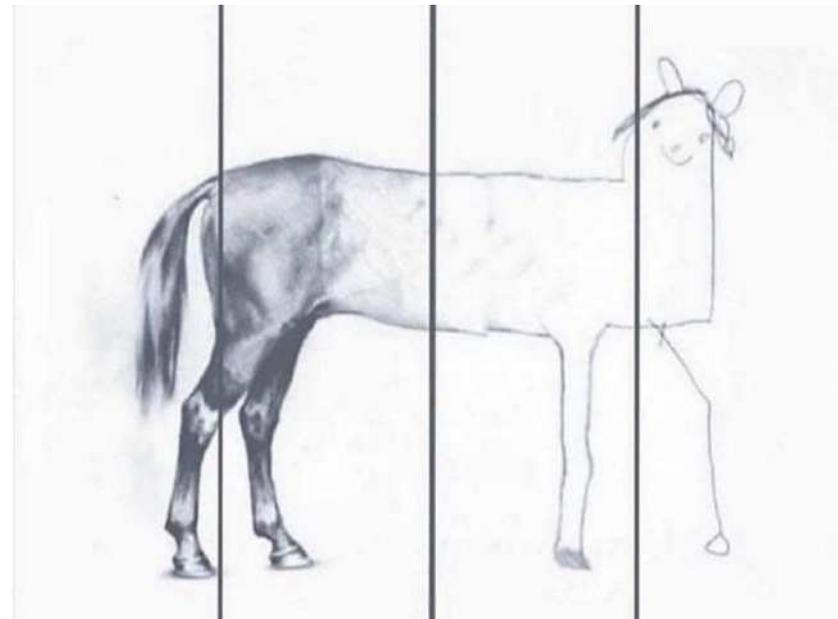


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Monitoring soil Temperature is Critical

- One measurement: late morning ~11AM
- Two measurement: (early morning + late afternoon) / 2



Day 1

Day 2

Day 3

Day 4



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Fungicide Selection Matters – Cool-Season

Chemical Control of Turfgrass Diseases 2024

Bruce B. Clarke (Emeritus), Department of Plant Biology, Rutgers University;
Paul Vincelli, Department of Plant Pathology, University of Kentucky;
Paul Koch, Department of Plant Pathology, University of Wisconsin-Madison;
Ming-Yi Chou, Department of Plant Biology, Rutgers University;

<https://publications.ca.uky.edu/files/PPA1.pdf>

 Cooperative Extension Service

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MADISON



24. Summer Patch

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy*	Interval (days) or Applications (x)
azoxystrobin: Heritage	11	3.5	14-28
<i>Bacillus amyloliquefaciens</i> strains PTA-4838 : Zorda	BM02	2	7
fludioxonil: Medallion, Pendant	12	L	14
fluoxastrobin: Fame, Floxcor	11	3.5 ^b	14-28
flutriafol: Rayora	3	3 ^b	2 x @ 21-28
fluxapyroxad: Xzemplar	7	2.5	14-28
hydrogen dioxide: Zerotol	NC	L	7
mefentrifluconazole: Maxtima	3	3 ^b	21-28
metconazole: Tourney	3	3	14
mineral oil: Civitas	NC	L ^c	7
myclobutanil: Eagle	3	3	28
penthiopyrad: Velista	7	2.5 ^d	14-28
propiconazole: Banner Maxx, Spectator, Savvi	3	3	14-28
prothioconazole: Densicor, Prothioconazole Select	3	3 ^e	14-28
pyraclostrobin: Insignia Intrinsic	11	3.5	14-28
tebuconazole: Torque, Mirage Stressgard, Clearscape ETQ, Offset, TEB360	3	3	14-28
thiophanate-methyl: 3336 EG, Fungo, Systec 1998, Cavalier, T-Storm	1	2.5	10-21
triadimefon: Bayleton	3	3	30
trifloxystrobin: Compass	11	3	21-28



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Fungicide Selection Matters – Warm-Season

Fungicide and Formulation ¹	Amount of Formulation ²	Application Interval (Days) ³	Efficacy Rating	Resistance Risk	FRAC Code ⁴						
						isofetamid + tebuconazole (Tekken)*	3	14 to 28	+++	Low	7/3
azoxystrobin (Heritage)			+++	Low	11	mefentrifluconazole (Maxtima)*	0.8	28	+++	Low	3
WG	0.4	28				mefentrifluconazole + pyraclostrobin (Navicon)*	0.7 to 0.85	14 to 28	++++	Low	3/11
TL	2	28				propiconazole (Banner MAXX)	2 to 4	14 to 28	+++	Low	3
G	2 to 4 lbs.	28				prothioconazole (Densicor)*	0.196	14 to 28	+++	Low	3
azoxystrobin + acibenzolar-S-methyl (Heritage Action)*	0.4	28	+++	Low	11/P01	pydiflumetofen + azoxystrobin + propiconazole (Posterity XT)*	1.5 to 3	14 to 28	++++	Low	7/11/3
azoxystrobin + difenoconazole (Briskway)*	0.5 to 1.2	14 to 28	++++	Low	11/3	pyraclostrobin (Insignia)	0.7	14 to 28	+++	Low	11
azoxystrobin + propiconazole (Headway)	0.75 to 3	14 to 28	++++	Low	11/3	tebuconazole (Torque)* (Mirage)*	0.6 to 1.1	14 to 28	+++	Low	3
azoxystrobin + propiconazole (Compendium)	2.6	28	++++	Low	11/3	triadimefon (Bayleton)	2	28	+++	Low	11/3
fluidapyr + flutriafol (Kalida)	0.25 to 0.4	14 to 21	+++	Low	7/3	trifloxystrobin + triadimefon (Tartan)	2	28	+++	Low	11/3
fluopyram + prothioconazole + propamocarb (Resilia)*	4	14 to 28	++++	Low	7/3/28						
fluxapyroxad + pyraclostrobin (Lexicon)	0.34 to 0.47	14 to 28	+++	Low	7/11						

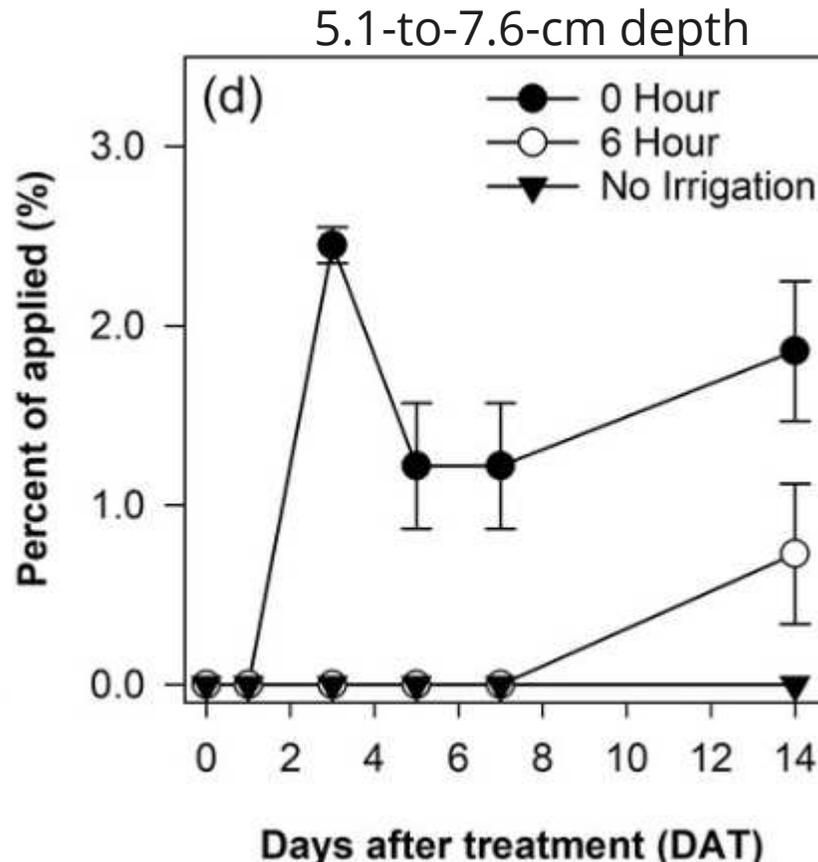
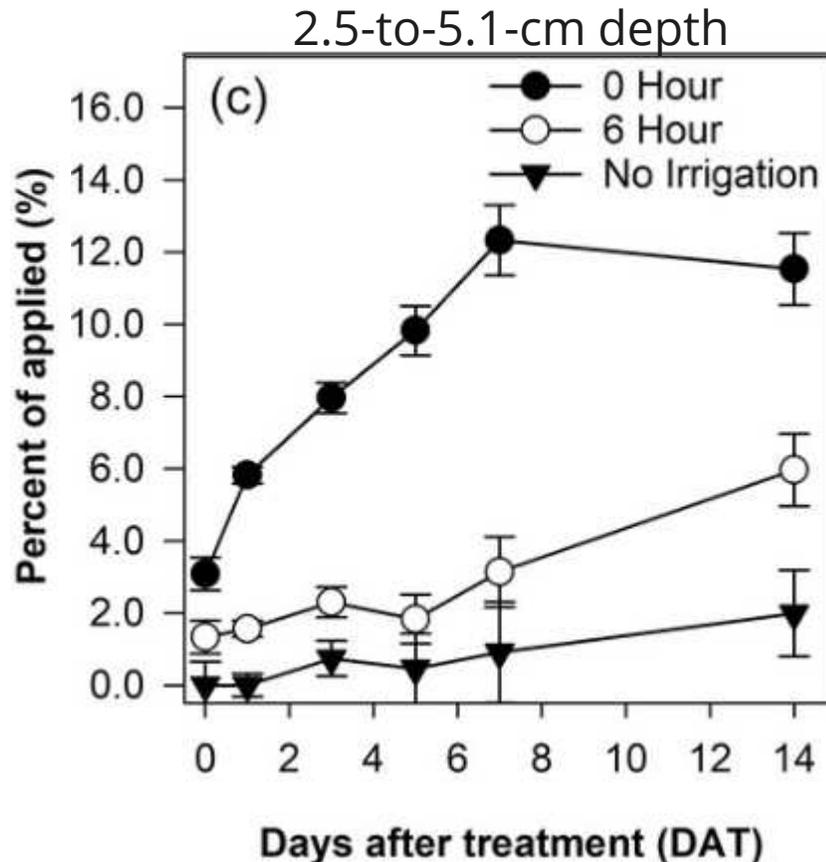


NC STATE UNIVERSITY

<https://www.turffiles.ncsu.edu/take-all-root-rot-in-turf/>

Post-Application Irrigation is Critical

- Irrigate 3-6 mm right after fungicide application
- Better late than never



Timing and Chemistry Validation



Dr. Lee Miller, Purdue University



Dr. Ming-Yi Chou, Rutgers University

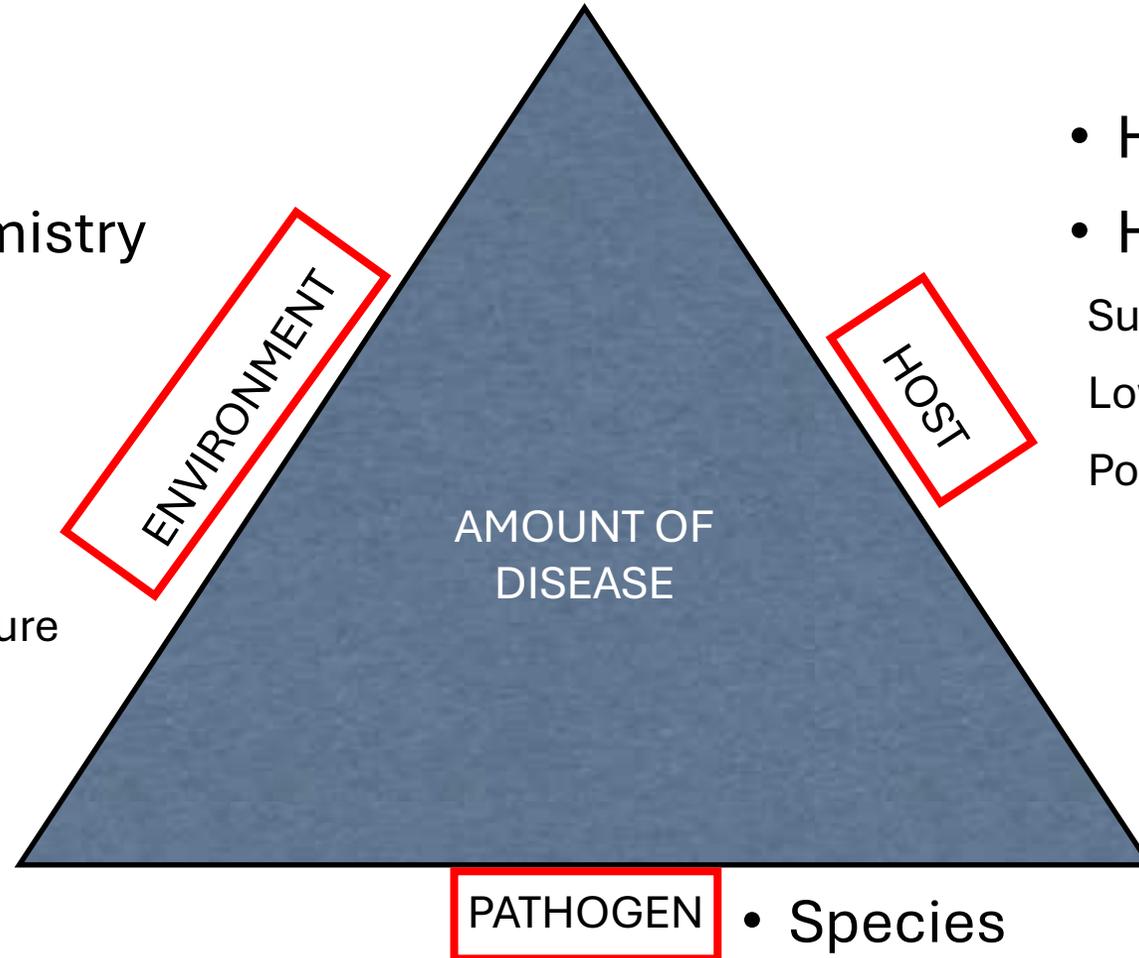
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Predisposing factors for diseases

- Water
- Physics and chemistry
 - Poor drainage
 - Thatch accumulation
 - High soil pH
 - Low available Mn
 - Moderate soil temperature



- Host genetics
- Host health
 - Susceptible species/cultivars
 - Low vigor
 - Poor rooting

- Species
- Fungicide

Host Genetics - Your First Line of Defense

Turfgrass Trial Explorer

1. Choose cultivar or trial Help

Select a cultivar

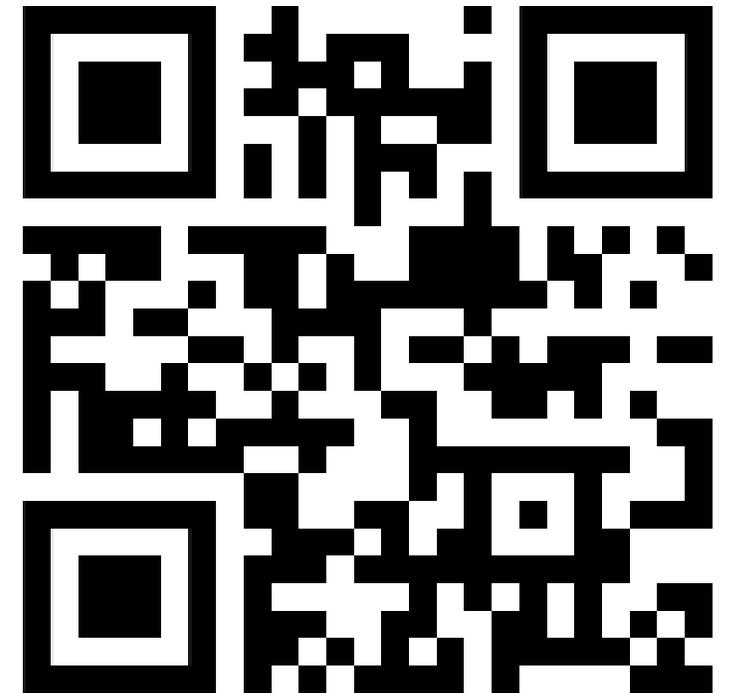
OR

2007 Bermudagrass - 2007-12

2. Choose variable(s) Variable guide

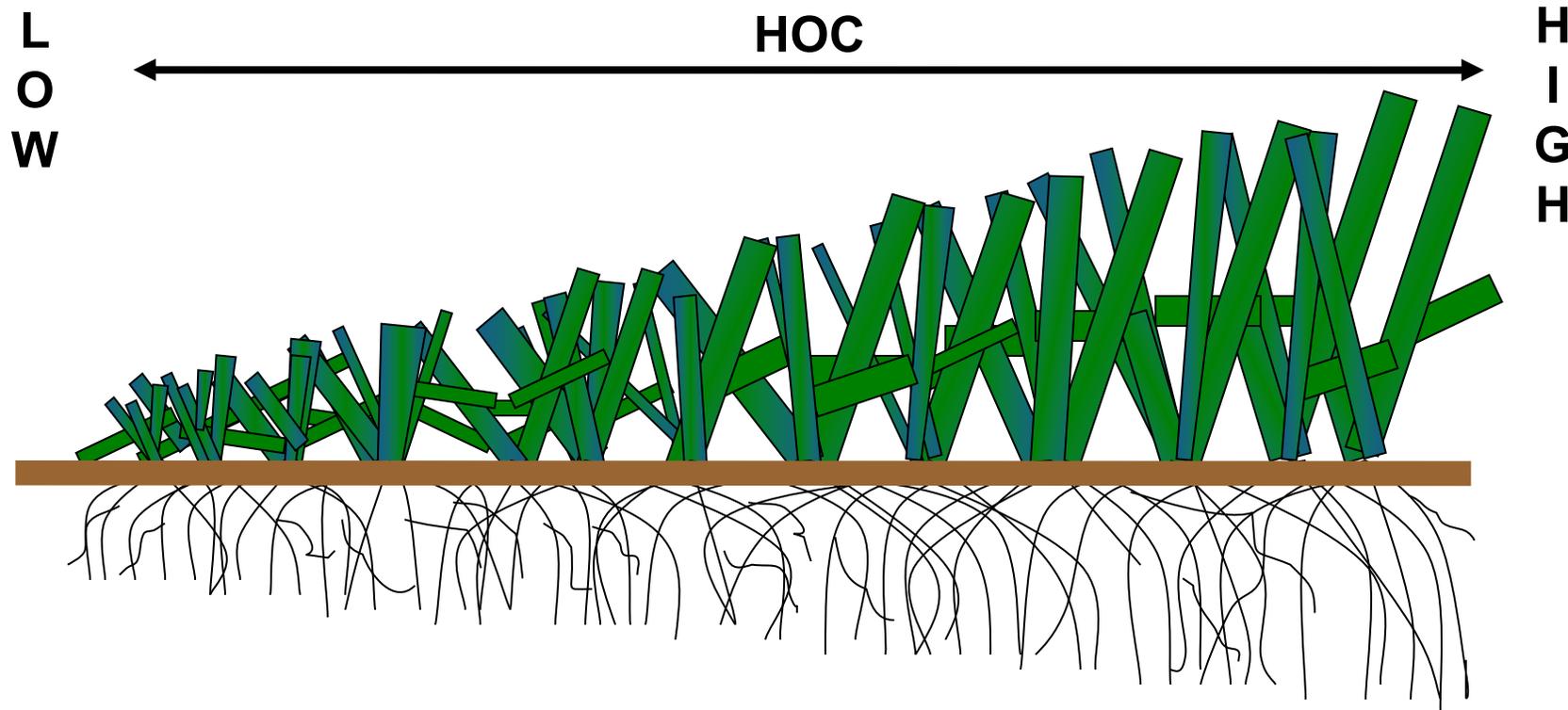
- DISEASES DAMPING OFF
- DISEASES FAIRY RING
- DISEASES GRAY LEAF SPOT
- DISEASES TAKE ALL ROOT ROT**
- COLOR OCTOBER
- COLOR NOVEMBER
- COLOR DECEMBER

NTEP Entry Name	Dallas, TX
C.V.	7.6
LSD	0.8
YUKON	8
BAR 7CD5	7.7
PSG 9Y2OK	7.7
PSG PROK	7.7
HOLLYWOOD	7.3
OKS 2004-2	7.3
PRINCESS 77	7.3
PYRAMID 2	7.3
RAD-CD1	7.3
SWI-1057	7.3
SWI-1122	7.3
TIFWAY	7.3
EMINENCE	7
GOLD GLOVE	7
MIDLAWN	7
NUMEX SAHARA	7
PSG 91215	7
RIVIERA	7
ROYAL BENGAL	7
SUNSPORT	7
SWI-1081	7
SWI-1083	7
SWI-1117	7
VERACRUZ	7
LATITUDE 36	6.7
PATRIOT	6.7
PSG 94524	6.7
SWI-1113	6.7
IS-01-201	6.3
PREMIER	5.7
NORTHBRIDGE	3.7



<https://maps.umn.edu/ntep/>

Height of Cut and Rooting



Rooting depth and density increases with \uparrow Height
Carbohydrate production increases with \uparrow Height



Roles of Mn in ERI Diseases

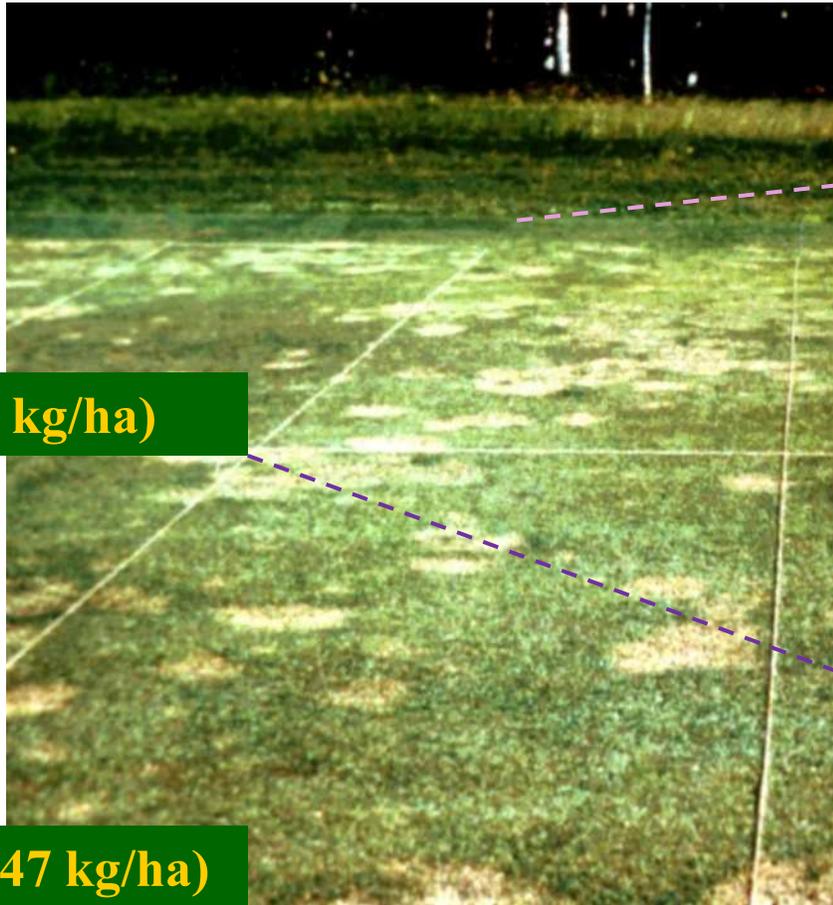
- *G. graminis* oxidizes Mn the rhizosphere rendering it unavailable to the plant
- High soil pH also reduces Mn availability
- Result in a localized deficiency of Mn
- Mn is needed to produce phytoalexins (anti-fungal)
- Foliar Mn applications reduces take-all severity



RUTGERS

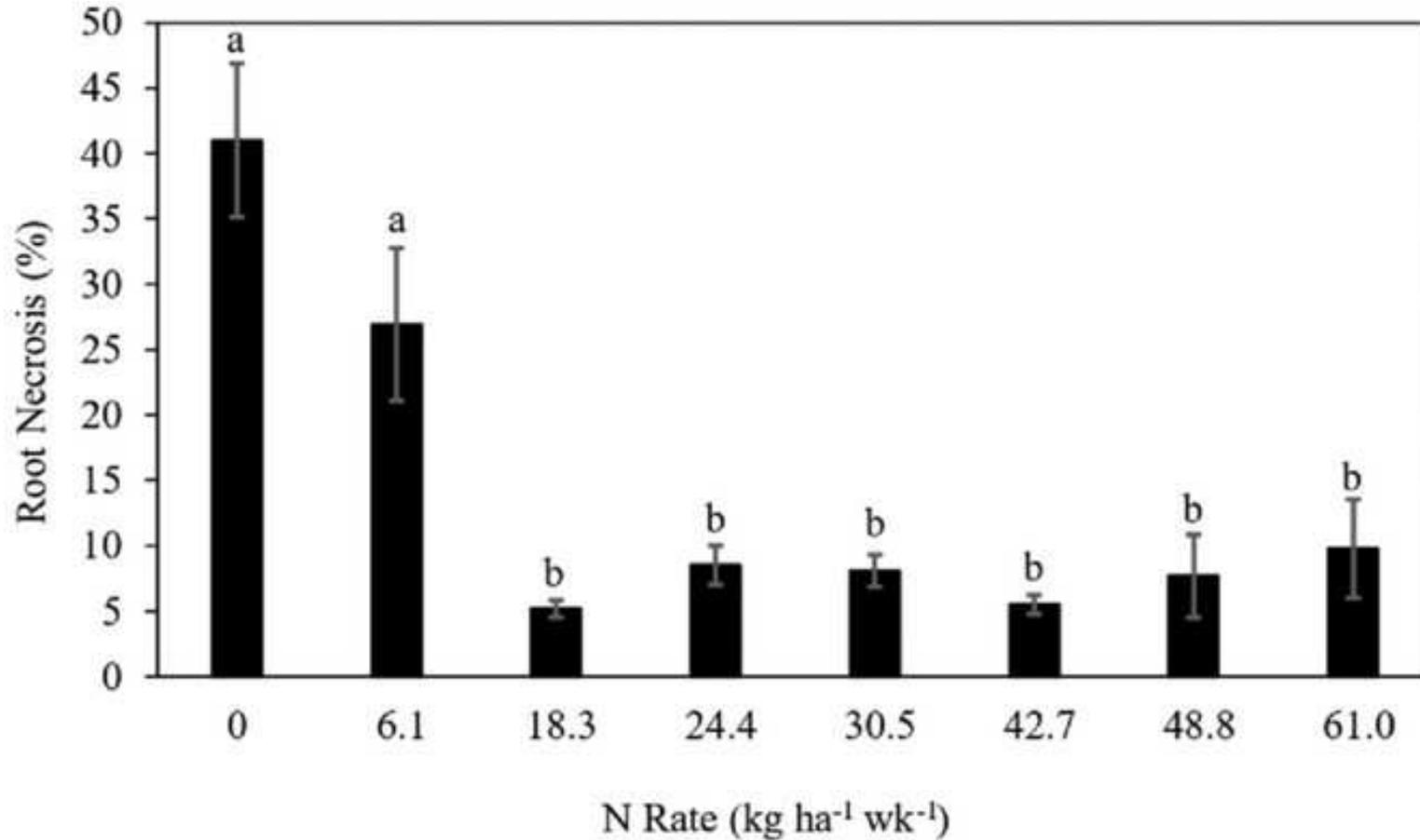
New Jersey Agricultural Experiment Station
Center for Turfgrass Science

Roles of Mn in Take-All Patch (Cool-Season)



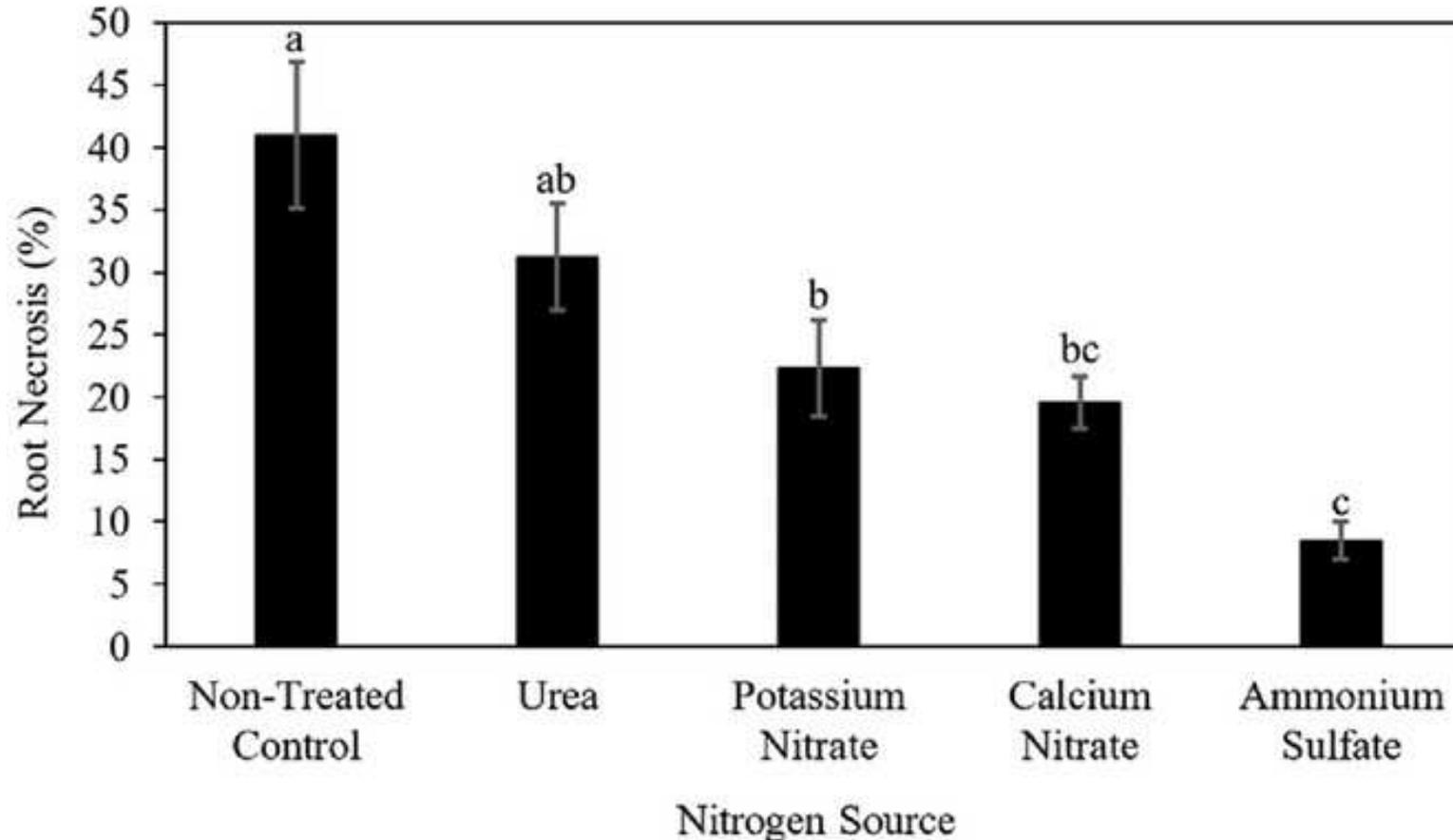


Roles of N Rate in Take-All Root Rot (Warm-Season)



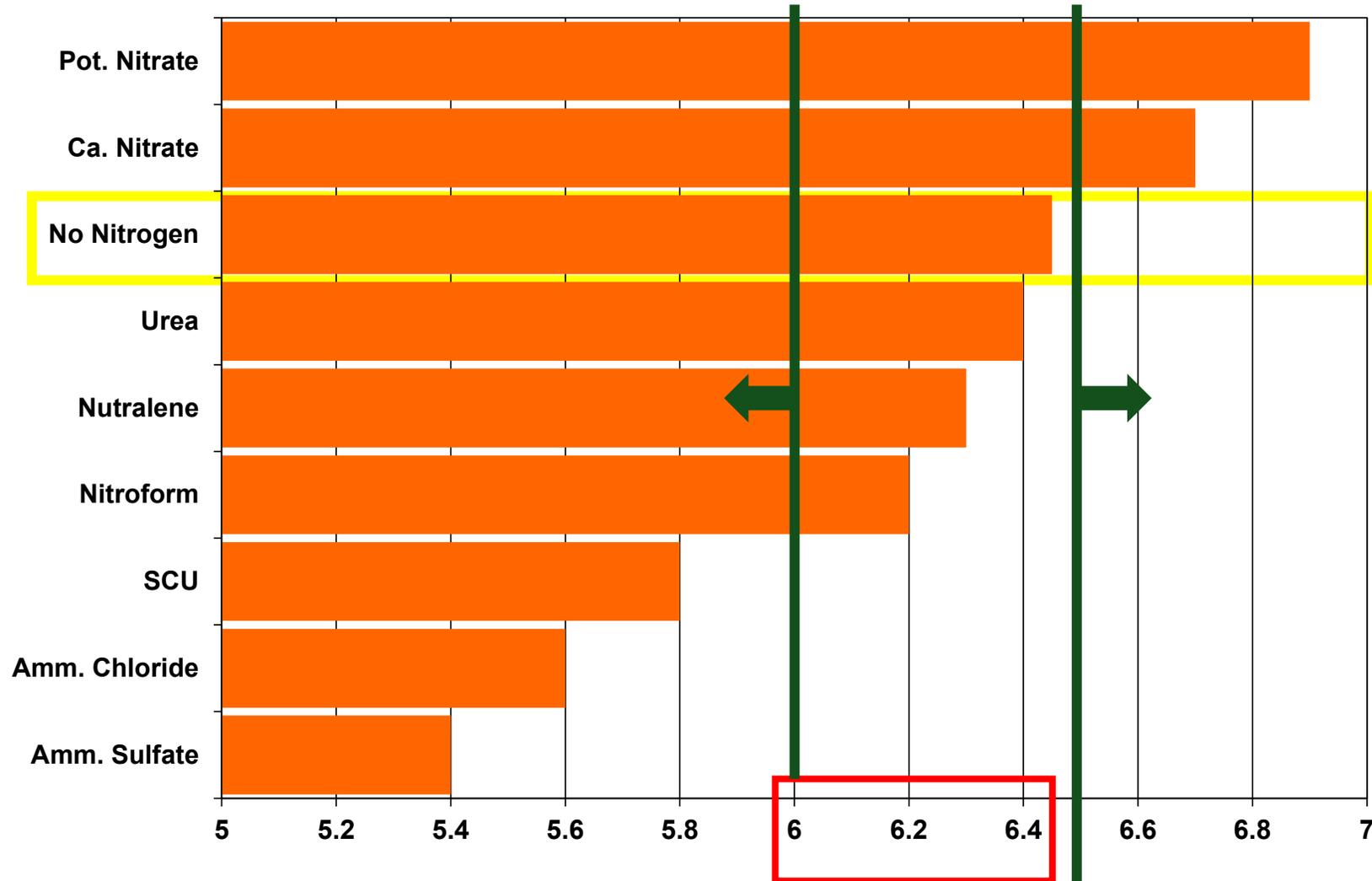


Roles of N Source in Take-All Root Rot (Warm-Season)



N rates were applied at 24.4 kg ha⁻¹ week⁻¹ for 8 weeks

Acidification of Soil by Nitrogen Source (196 kg/ha) / year



Outline

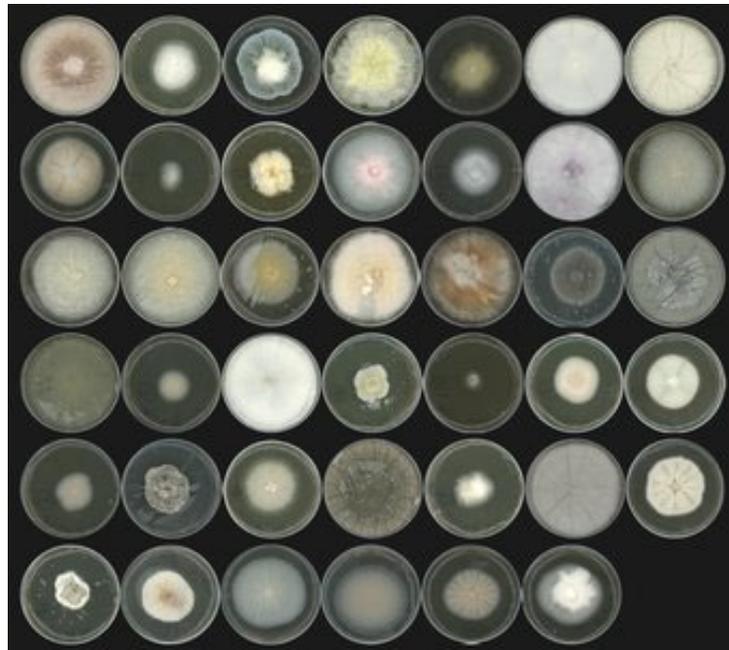
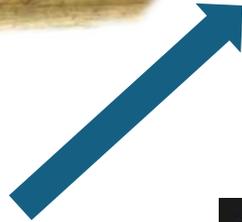
- Introduction to ERI fungal diseases
- Predisposing factors for ERI diseases
- How to manage ERI fungal diseases – chemical control
- How to manage ERI fungal diseases – cultural practices
- A new tool



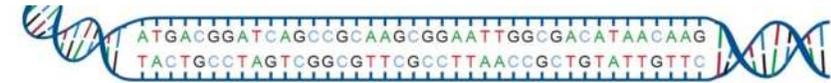
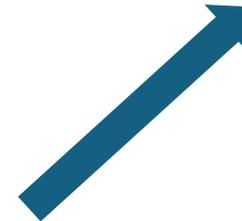
Pathogen isolation

Select 10-20 infected roots

Incubation in varied temperatures



Picture by Max Planck Institute



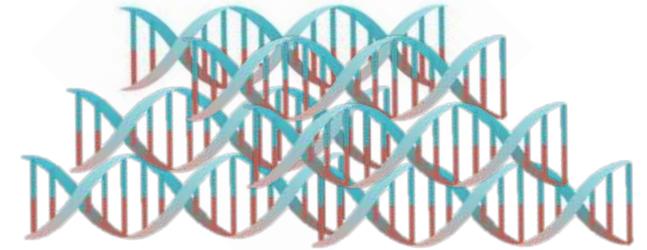
Identification

High-throughput sequencing

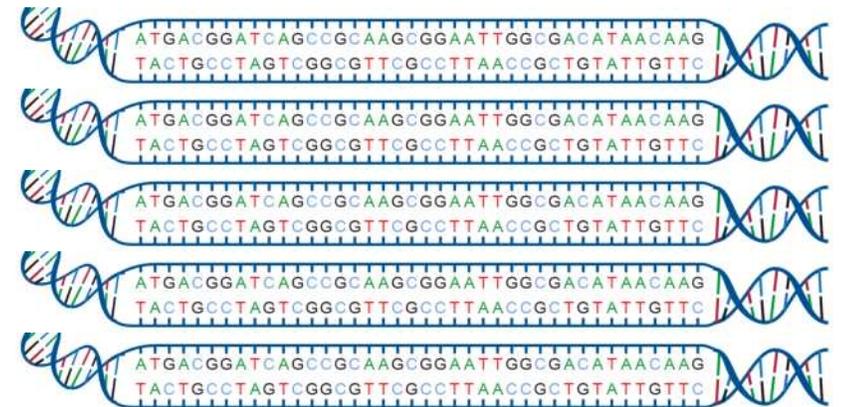
Select 10-20 infected roots



Community DNA



High-throughput sequencing

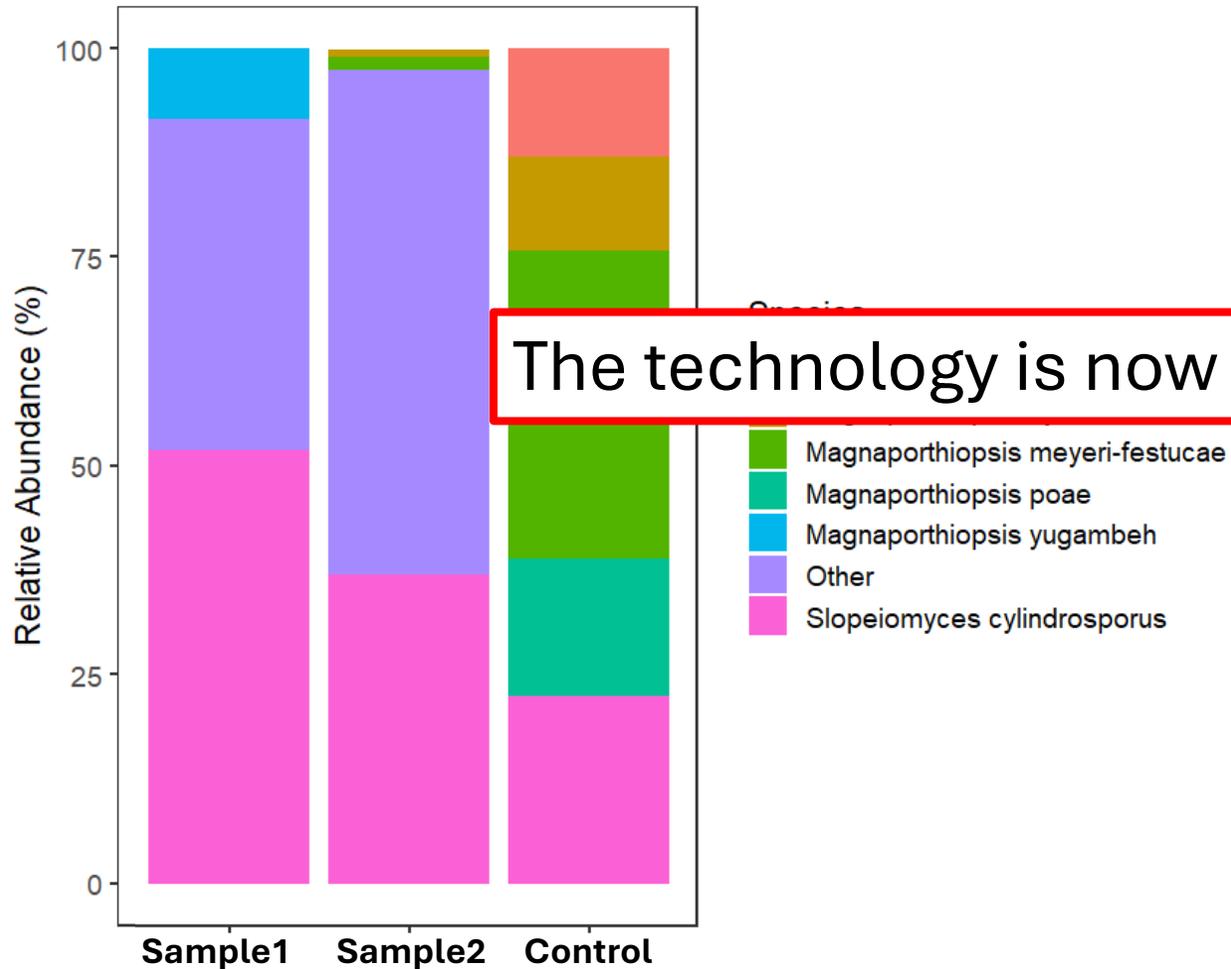


Taxonomic assignment

Sequence	Species	Reads#
Seq1	<i>Slopeiomyces cylindrosporus</i>	33
Seq2	<i>Magnaporthiopsis meyeri-festucae</i>	10
Seq3	<i>Magnaporthiopsis poae</i>	20
Seq4	<i>Gaeumannomyces avenae</i>	24
Seq5	<i>Magnaporthiopsis yugambeh</i>	13



ERI pathogen profiling



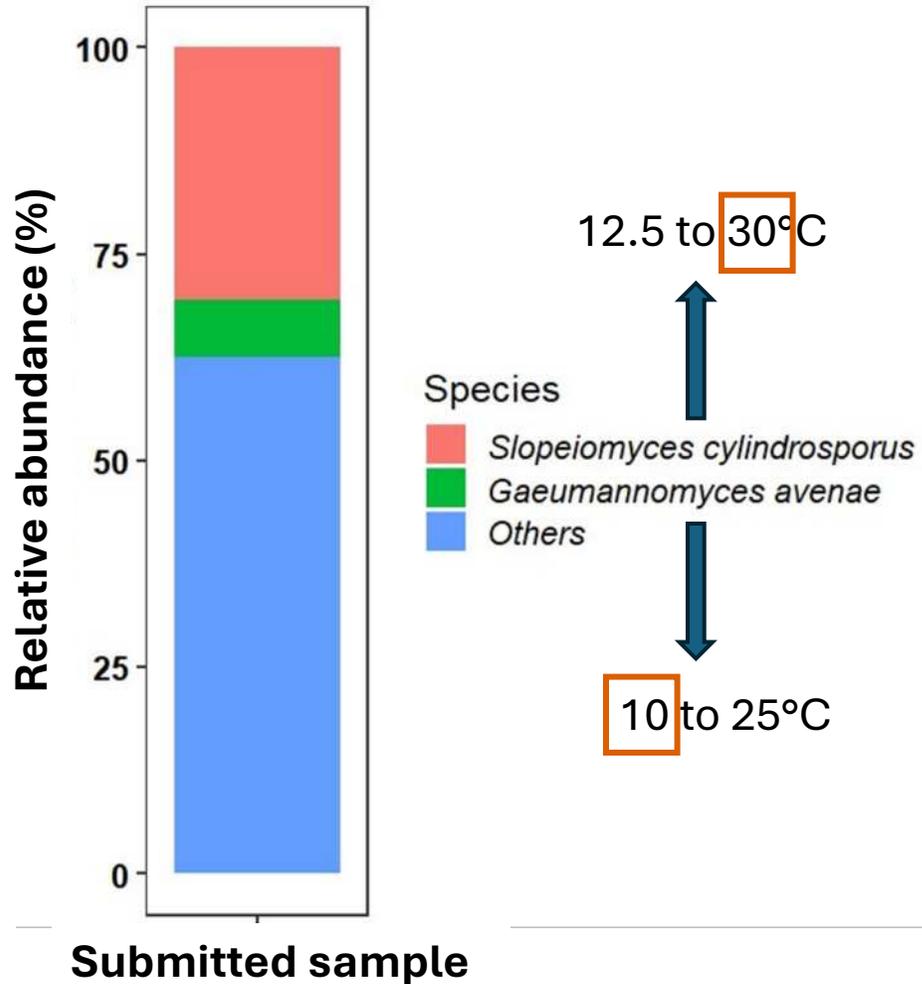
The technology is now available to all of you!!!

- Control: Confirmed resolution
- Sample 1: Two species as potential culprits
- Sample 2: Three species as



<https://tinyurl.com/RootProfile>

Example ERI pathogen profiling



Thank You for Listening



Resources

Useful tools to help you manage turfgrass diseases

Disease predictive models

[Dollar spot using zip code](#)
(by Syngenta)

[Dollar spot using your local weather station](#)
(by UW-Madison) – under “How can you use the model?” section

[Multiple disease models for the Northeast](#)
(by Cornell University) – anthracnose. dollar soot. brown patch. pythium – under “disease/stress risk” tab

[Predicted global soil temperature by city](#)
(by Soil Temperature App)

Soil temperature map
[Using zip code](#)
(by Syngenta) – perfect to time your root disease applications

Fungicide efficacy rating
[Web-based](#)
(by UW-Madison) – mostly 2020 or earlier information

[PDF version](#)
(by Rutgers, UKY, and UW-Madison) – 2024 updated information

Turfgrass species and cultivar evaluation
[NTEP – turfgrass trial explorer](#)
[Rutgers proceedings](#)
(by Rutgers University Center for Turfgrass Science) – New Jersey specific results

Environmental Impact Quotient (EIQ) calculator
[Calculate pesticide EIQ now](#)
(by Cornell University)

Search this site

Search here..

Lab news

[Just published in AFM: Fungicide use vs disease suppressive microbiome in turf](#)
February 24, 2025

[Open Postdoc Position in Turfgrass Pathogen Population Genetics and Microbiome](#)
January 9, 2025

[Excited to be presenting at the GCSAA Conference 2025!](#)
January 5, 2025



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Questions?