

SUSTAINABLE TURFGRASS MANAGEMENT IN ASIA 2026



Harnessing the Turfgrass Microbiome for Sustainable Disease Control

March. 9th, 2026

Ming-Yi Chou, Ph.D.
mingyi.chou@rutgers.edu

Assistant Extension Specialist and Professor, Rutgers University

Outline

- What is microbiome?
- What are the functions of microbiome?
- Can we enrich the beneficial microbes?
- Can we cultivate healthy microbiome?
- Exploration of suppressive microbes
- Final thoughts



The microbiome is the community of microbes in a given habitat





RUTGERS

New Jersey Agricultural Experiment Station
Center for Turfgrass Science

Microbiome dictates soil processes



USDA IS AN EQUAL OPPORTUNITY PROVIDER AND EMPLOYER.

Healthy SOIL SECRETS



THERE ARE MORE SOIL MICROORGANISMS IN A TEASPOON OF HEALTHY SOIL THAN THERE ARE PEOPLE ON THE EARTH!



MILLIONS OF SPECIES AND BILLIONS OF ORGANISMS — BACTERIA, ALGAE, MICROSCOPIC INSECTS, EARTHWORMS, BEETLES, ANTS, MITES, FUNGI AND MORE — REPRESENT THE GREATEST CONCENTRATION OF BIOMASS ANYWHERE ON THE PLANET! MICROBES, WHICH MAKE UP ONLY ONE HALF OF ONE PERCENT OF THE TOTAL SOIL MASS, ARE THE YEASTS, ALGAE, PROTOZOA, BACTERIA, NEMATODES, AND FUNGI THAT PROCESS ORGANIC MATTER INTO RICH, DARK, STABLE HUMUS IN THE SOIL.

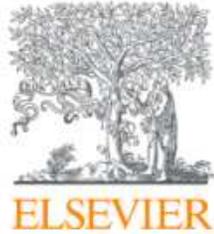
**WANT MORE
SOIL SECRETS?**

CHECK OUT
WWW.NRCS.USDA.GOV

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Applied Soil Ecology

Available online 2 February 2024, 105311

In Press, Corrected Proof [?](#) What's this? [↗](#)



Microbial diversity and soil health parameters associated with turfgrass landscapes

Ming-Yi Chou^{a d}, Dimitrios Pavlou^b, Pamela J. Rice^c, Kurt A. Spokas^c,
Douglas J. Soldat^b, Paul L. Koch^a [i](#) [e](#)

Bacterial and fungal community composition significantly correlated with soil **P, Fe, and C** content, **pH, organic matter**, sand and clay content, and the **overall soil health** rating.

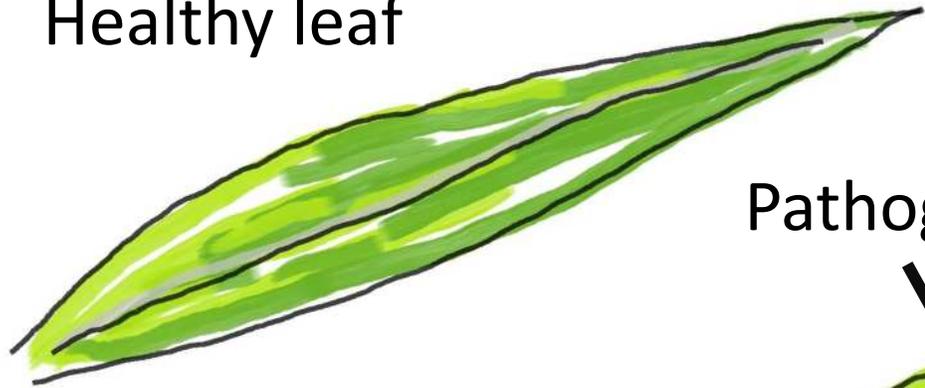
Pathogenic microbes in the community



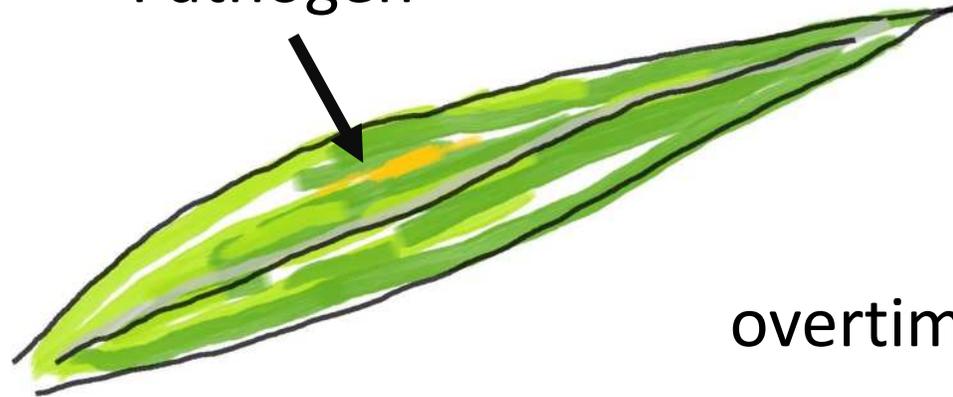
The breaking down of the “one-pathogen-one-disease” concept

One-pathogen-one-disease theory

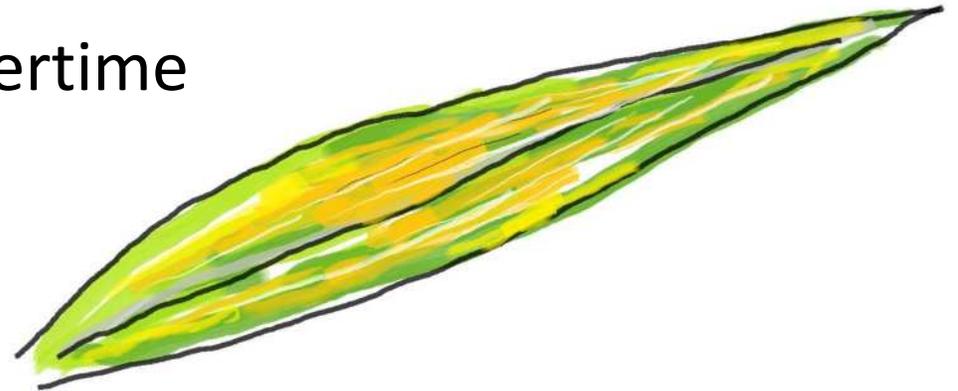
Healthy leaf



Pathogen

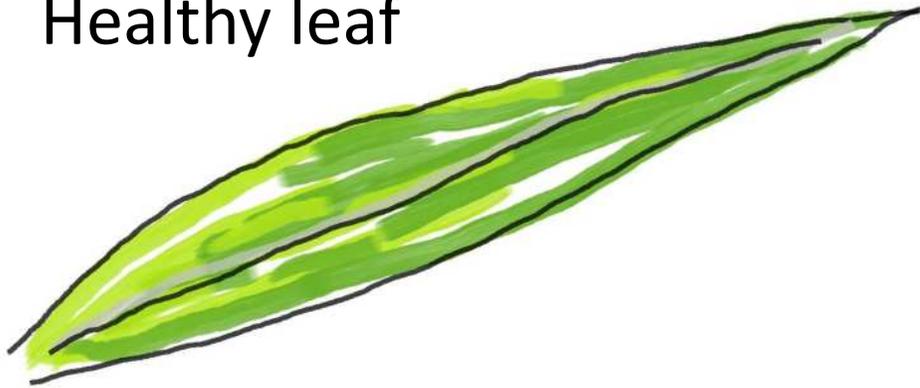


overtime

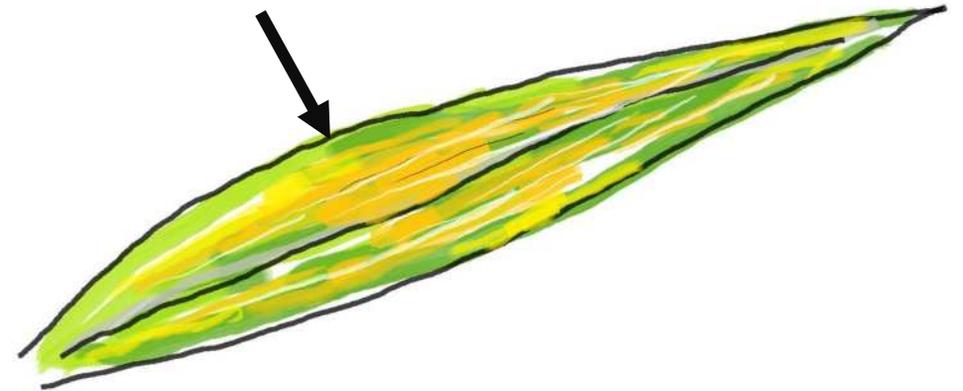


The breaking down of the “one-pathogen-one-disease” concept

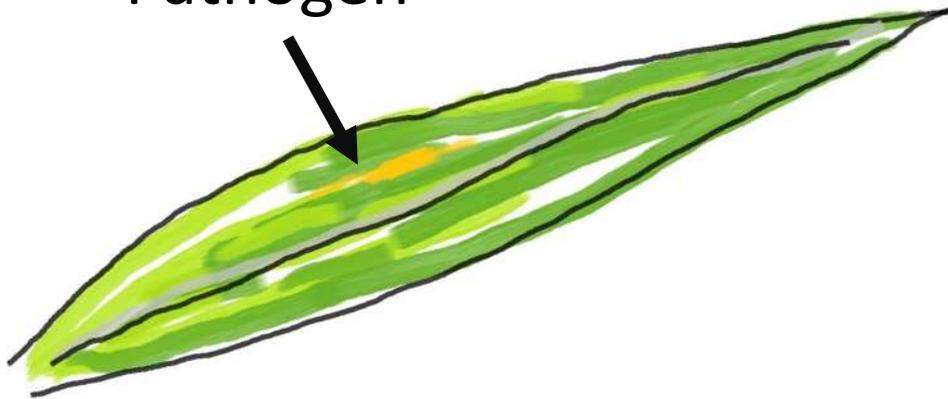
Healthy leaf



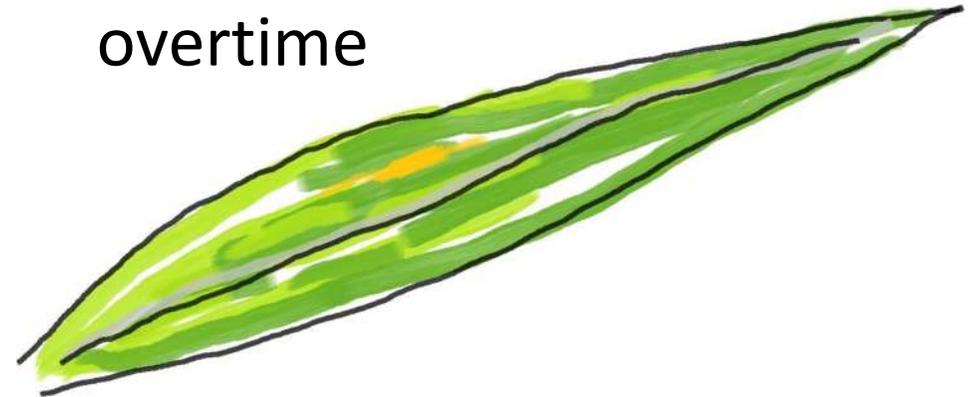
Pathogen + pathogenic facilitator



Pathogen

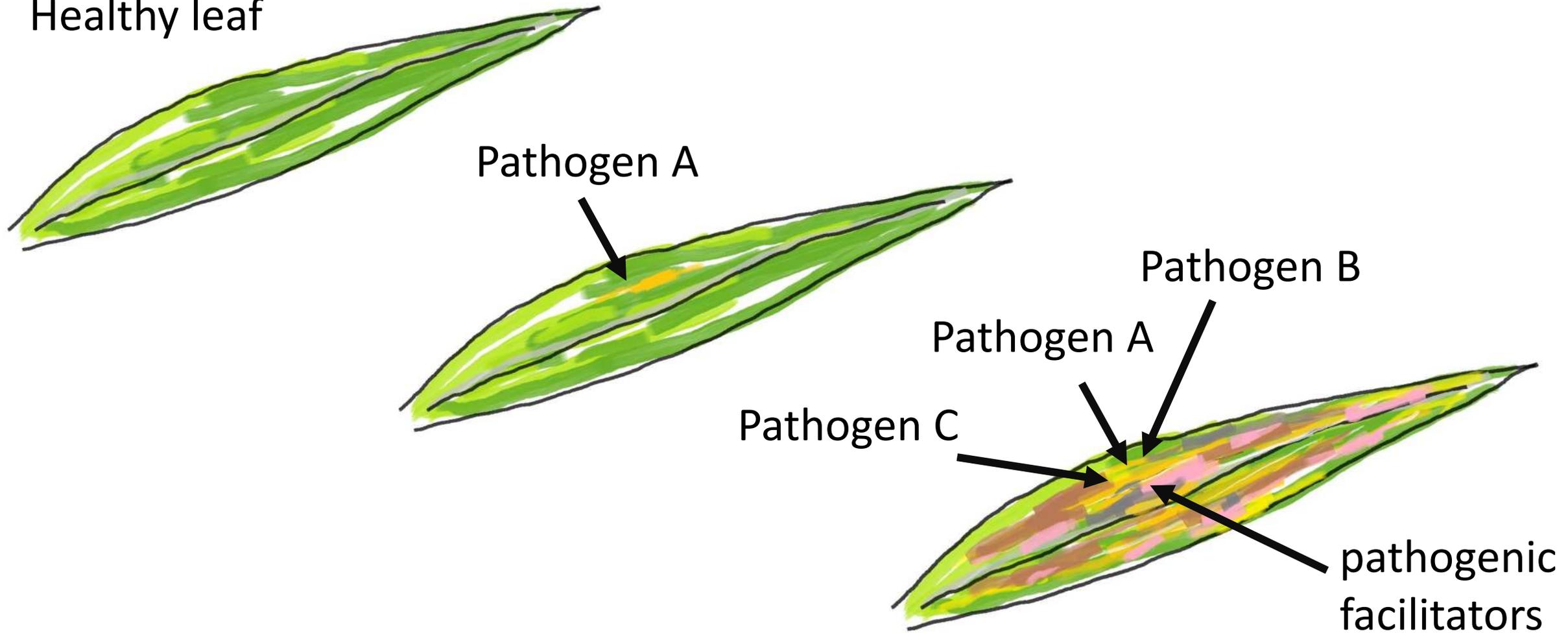


overtime



The breaking down of the “one-pathogen-one-disease” concept

Healthy leaf



Take-All Root Rot Pathogens on Bermudagrass



Photo by Jim Kerns, NCSU

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

Summer Patch and Take-all Patch Associated Pathogens



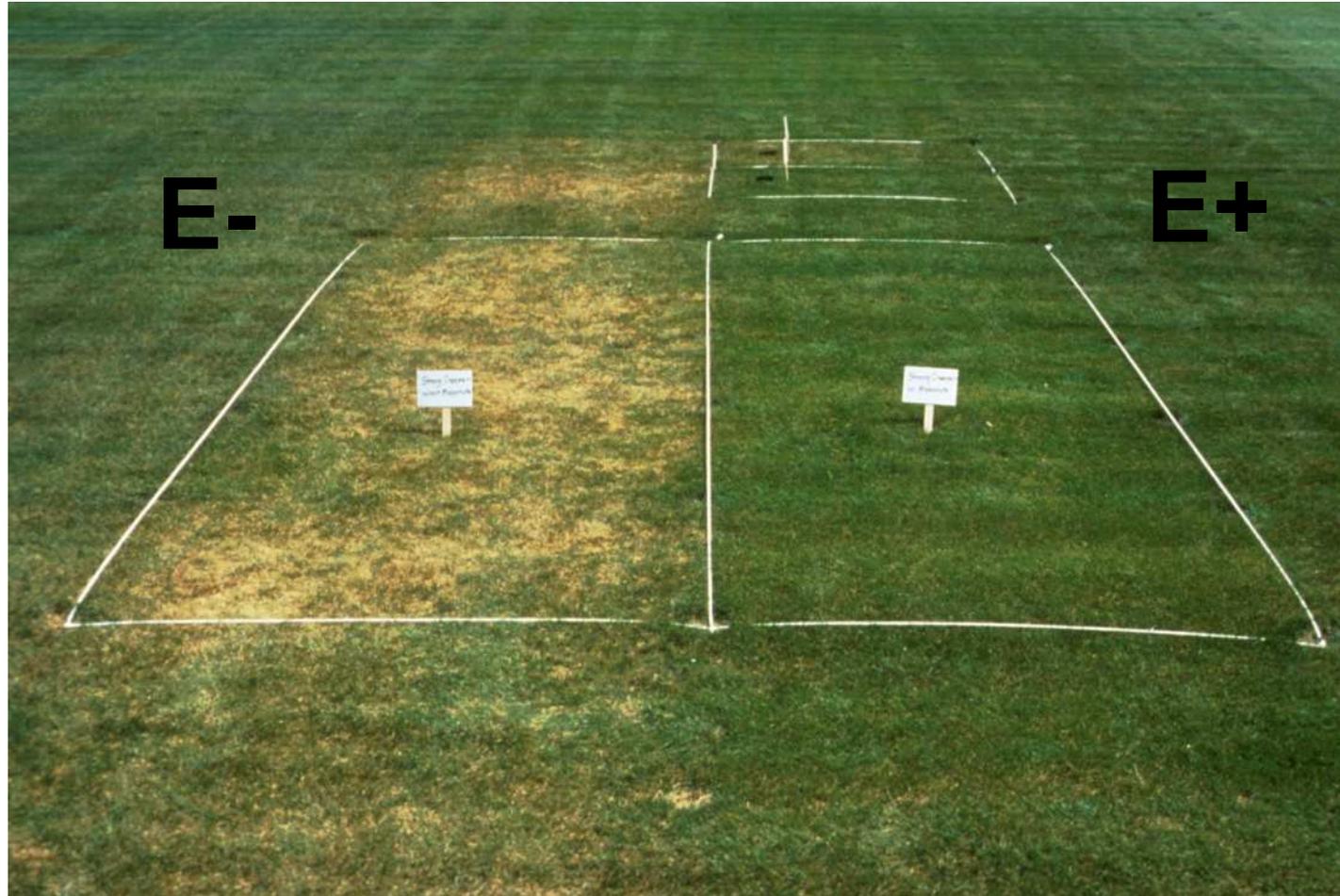
Magnaporthiopsis poae, *M. meyeri-festucaae*, *M. incrustans*, *M. cynodontis*, *M. yugambeh*, *Slopeiomyces cylindrosporus*, and *Gaeumannomyces avenae*

Beneficial microbes in the community



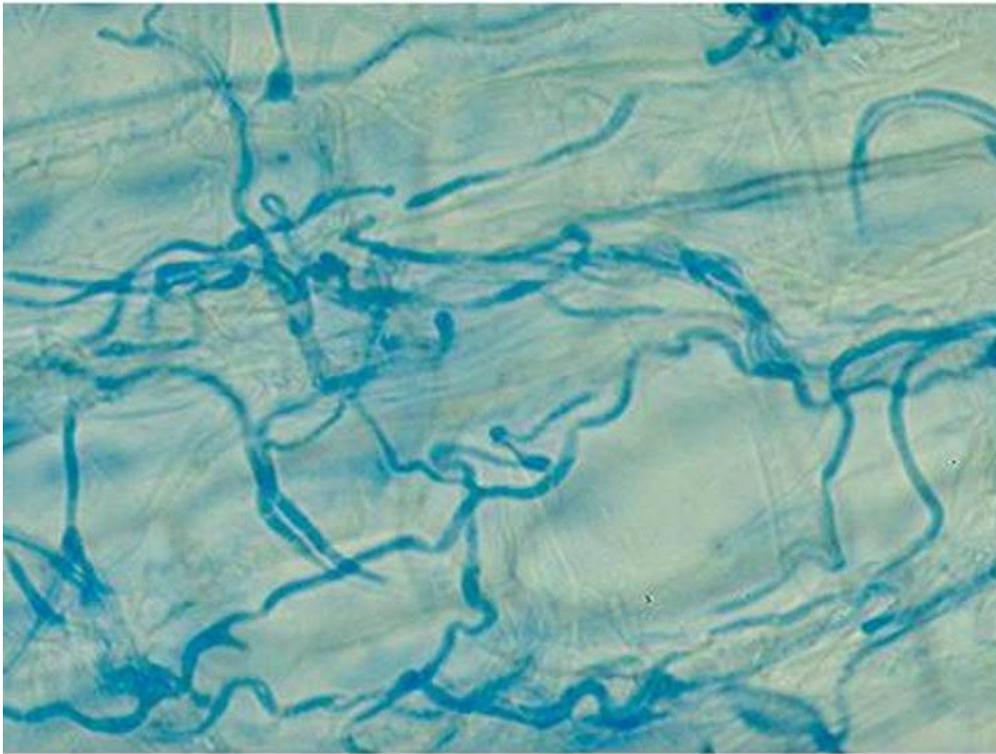
Beneficial microbes in turf

Severe disease on endophyte free creeping red fescue

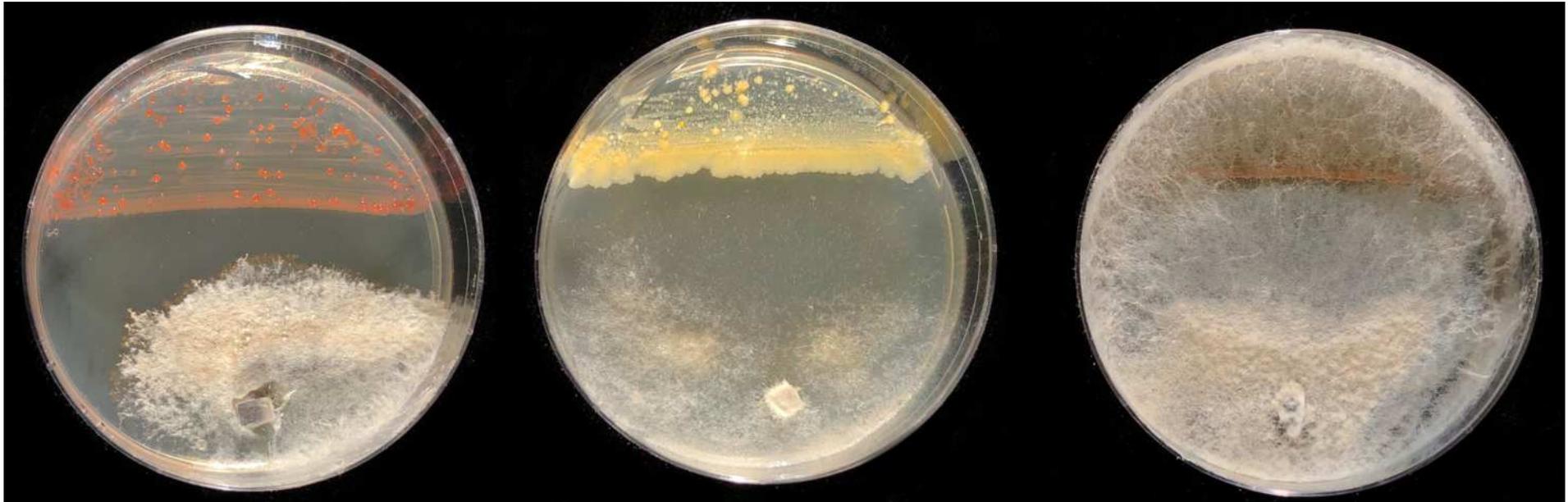


Beneficial microbes in turf

Neotyphodium endophyte

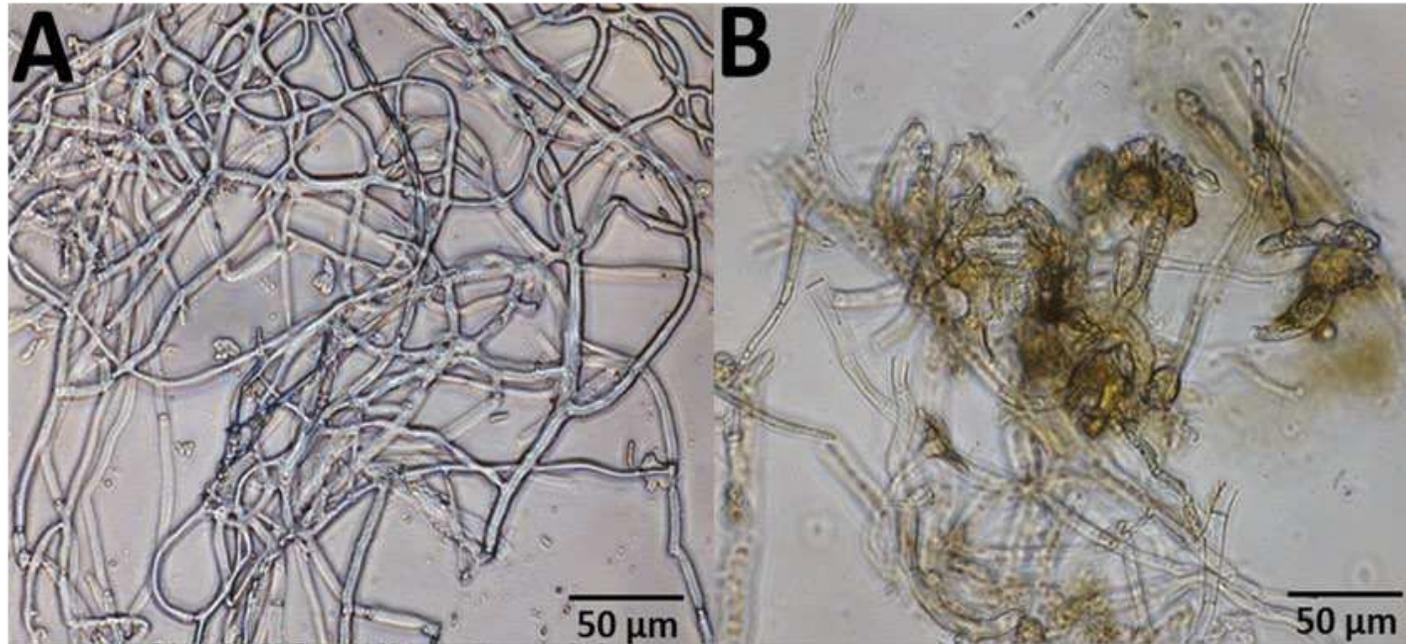


Beneficial microbes in the community



Clarireedia jacksonii

Beneficial microbes in the community



Fungicidal effects of beneficial bacteria

Outline

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- Final thoughts



Biological control products are available for turfgrass diseases



Actinovate® SP
BIOLOGICAL FUNGICIDE

EcoGuard™
BIOFUNGICIDE



DoubleNickel55™
BIOFUNGICIDE
Water Dispersible Granular Biofungicide

RHAPSODY®

Bacillus spp., Pseudomonas spp., and Streptomyces spp.

Dollar spot suppression with biocontrol product

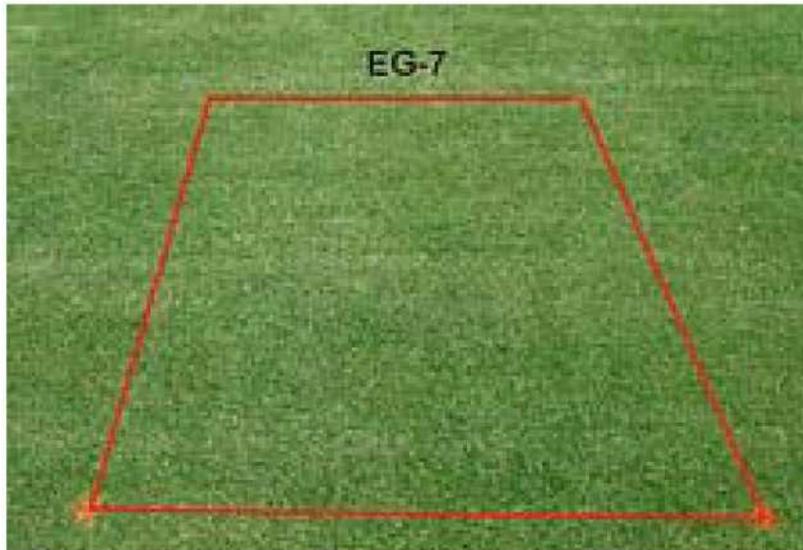


Fig. 1A. Tifgreen bermudagrass treated with EcoGuard applied every 7 days in the spring 2004 evaluation.

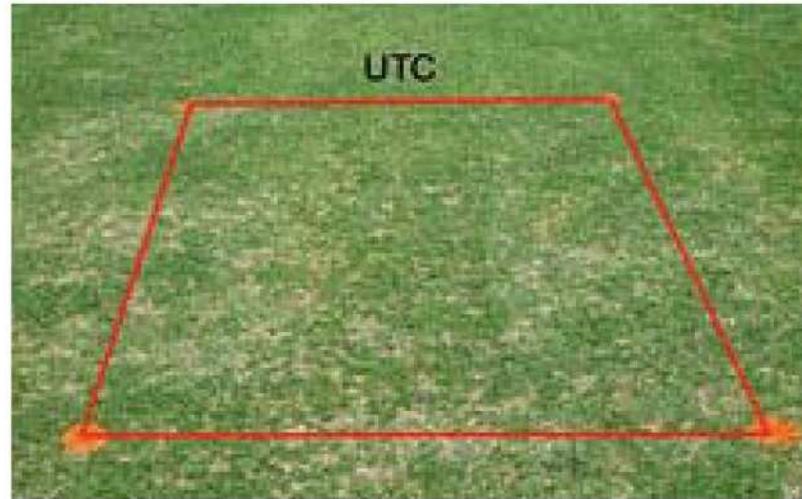
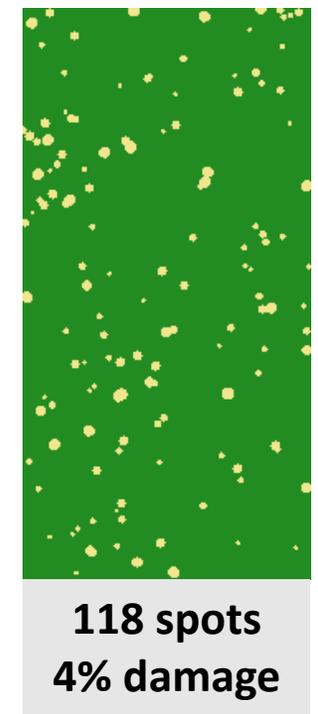
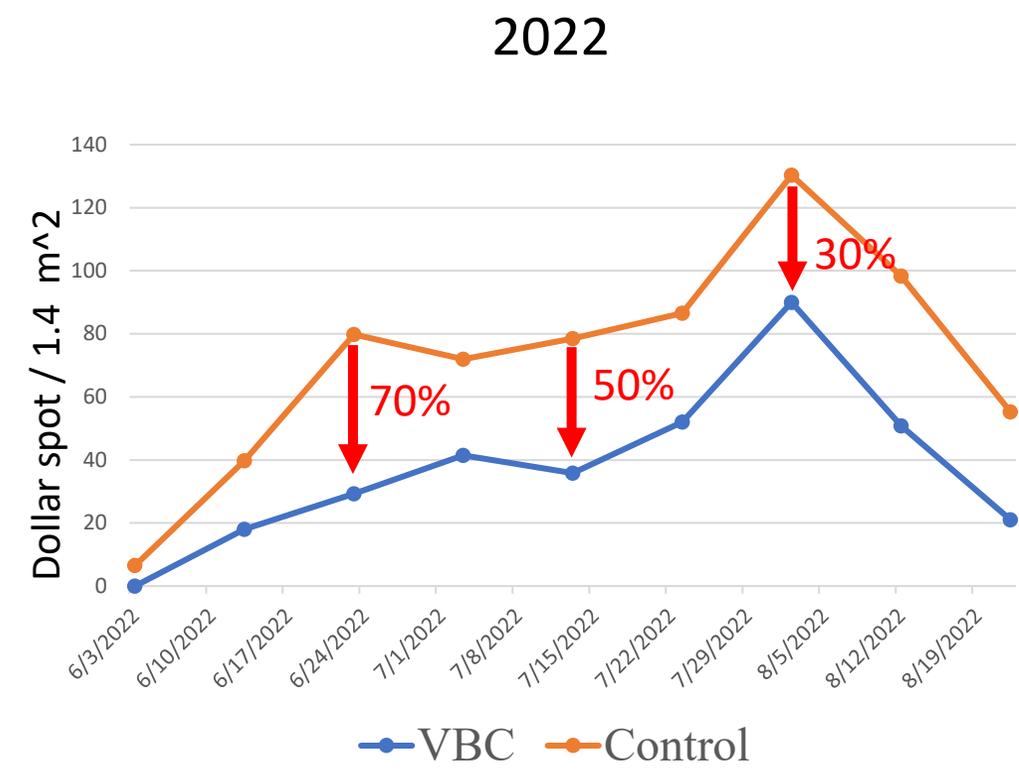
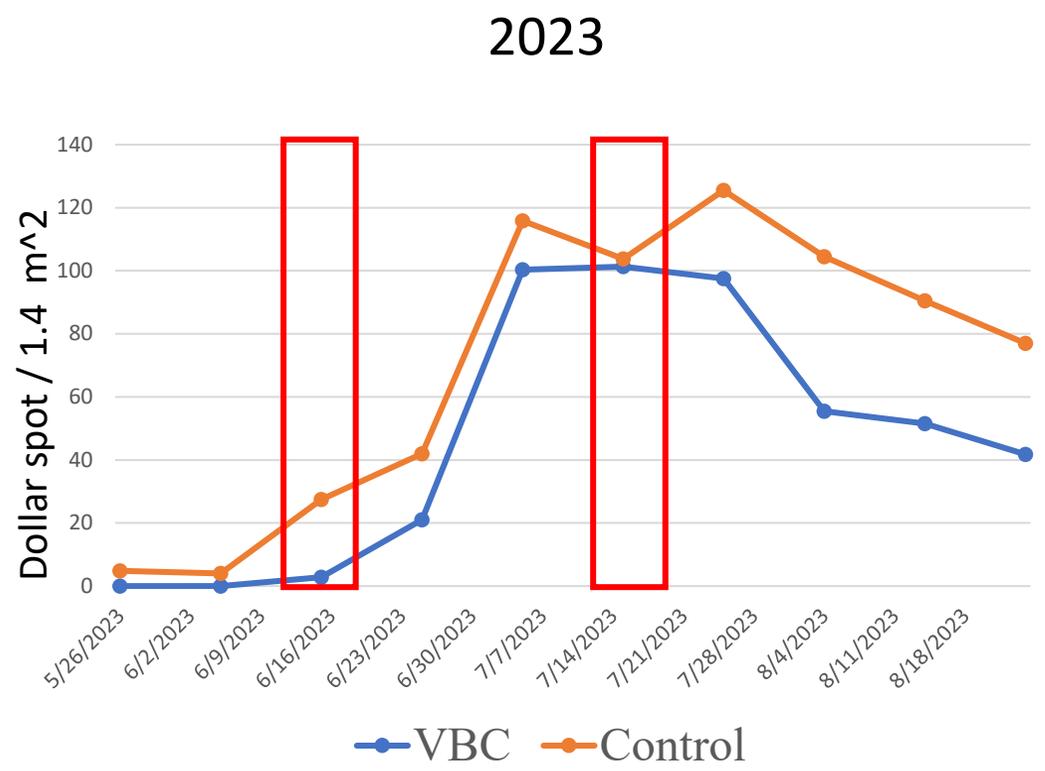


Fig. 1B. An untreated control plot of Tifgreen bermudagrass with high dollar spot severity in the spring 2004 evaluation.

Dollar spot suppression with biocontrol product



Bacillus amyloliquefaciens
13-year-old Crenshaw creeping bentgrass fairway at 1 cm

Summer patch suppression with biocontrol product

2023



Bacillus amyloliquefaciens
Zorda WG

1.34 g/m² - 7day

Control

18-year-old Baron Kentucky bluegrass rough at 4 cm

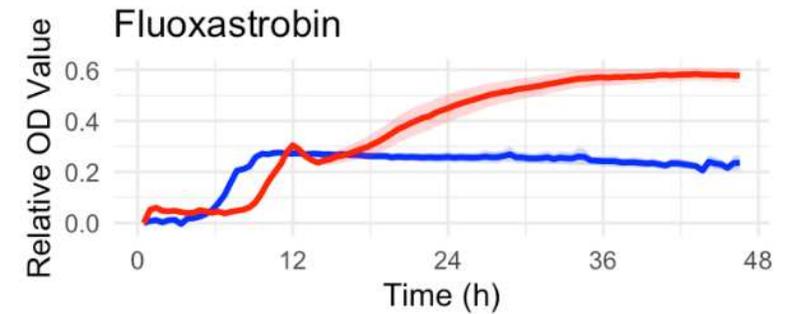
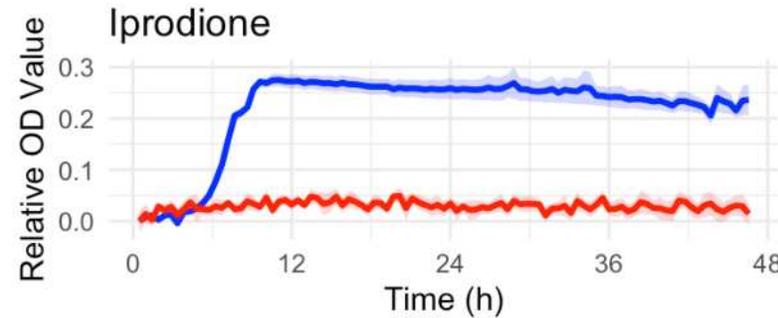
Working or not working – It's all about fitness



Survive → Establish Population → Function

Environmental Stresses Affect Microbial Fitness

- UV light
- Air humidity / Soil water
- Substrate availability
- pH
- Pesticides



Fungicide interaction with *B. amyloliquefaciens*

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Fungicide effects on turfgrass microbiome

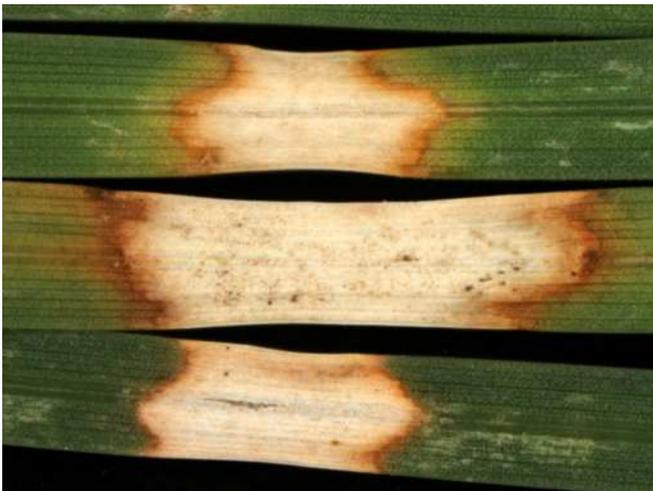


The Scientist Magazine®



Dollar spot

- Caused by fungus *Clarireedia* spp.
- 18-30°C day temperature / cool nights
- Cost more fungicide applications than any other turfgrass diseases (Kerns and Tredway 2013)



Leaf lesion



Mycelia under high humidity



Disease symptoms on putting green



Soil collection

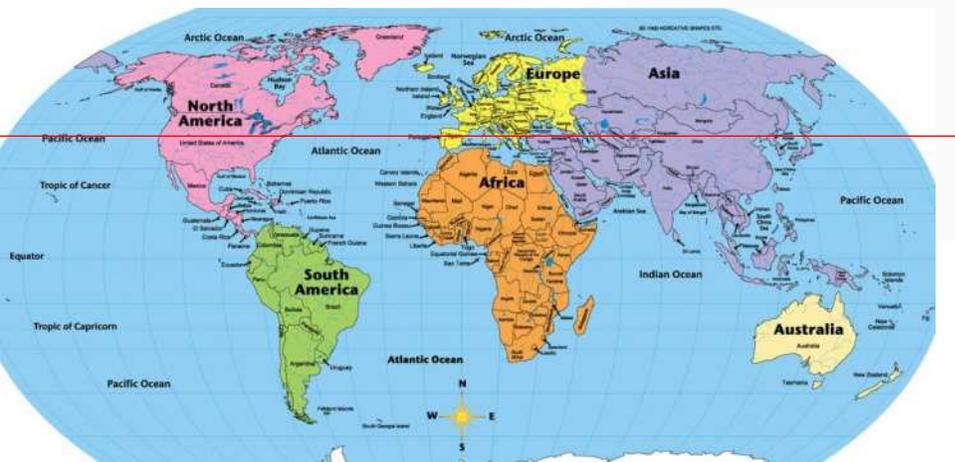
- 5 states (NJ, NY, MA, WI, and IL, USA)
- 4 high fungicide use / disease pressure courses
- 4 low fungicide use / disease pressure courses
- 8 total sites X 5 replications

Fairway soil were collected from the MW and NE

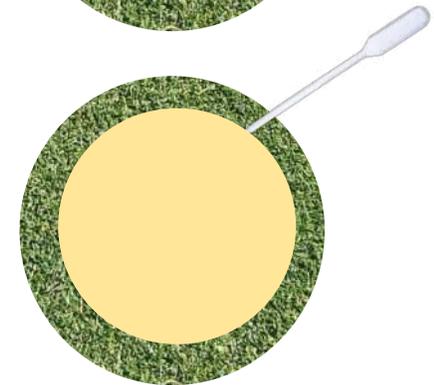
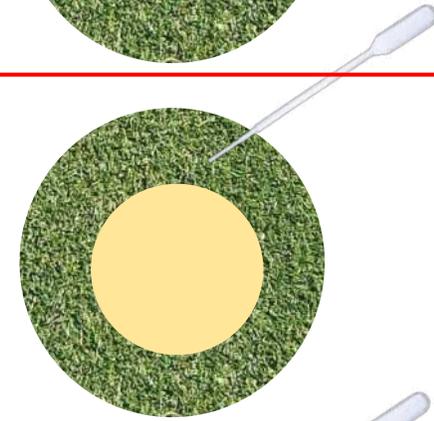
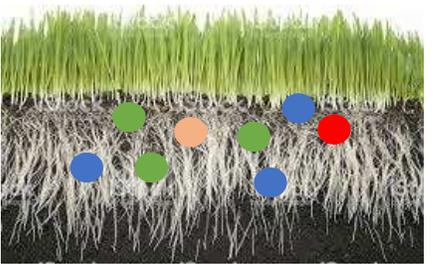
- **Golf course**
2 high
2 low

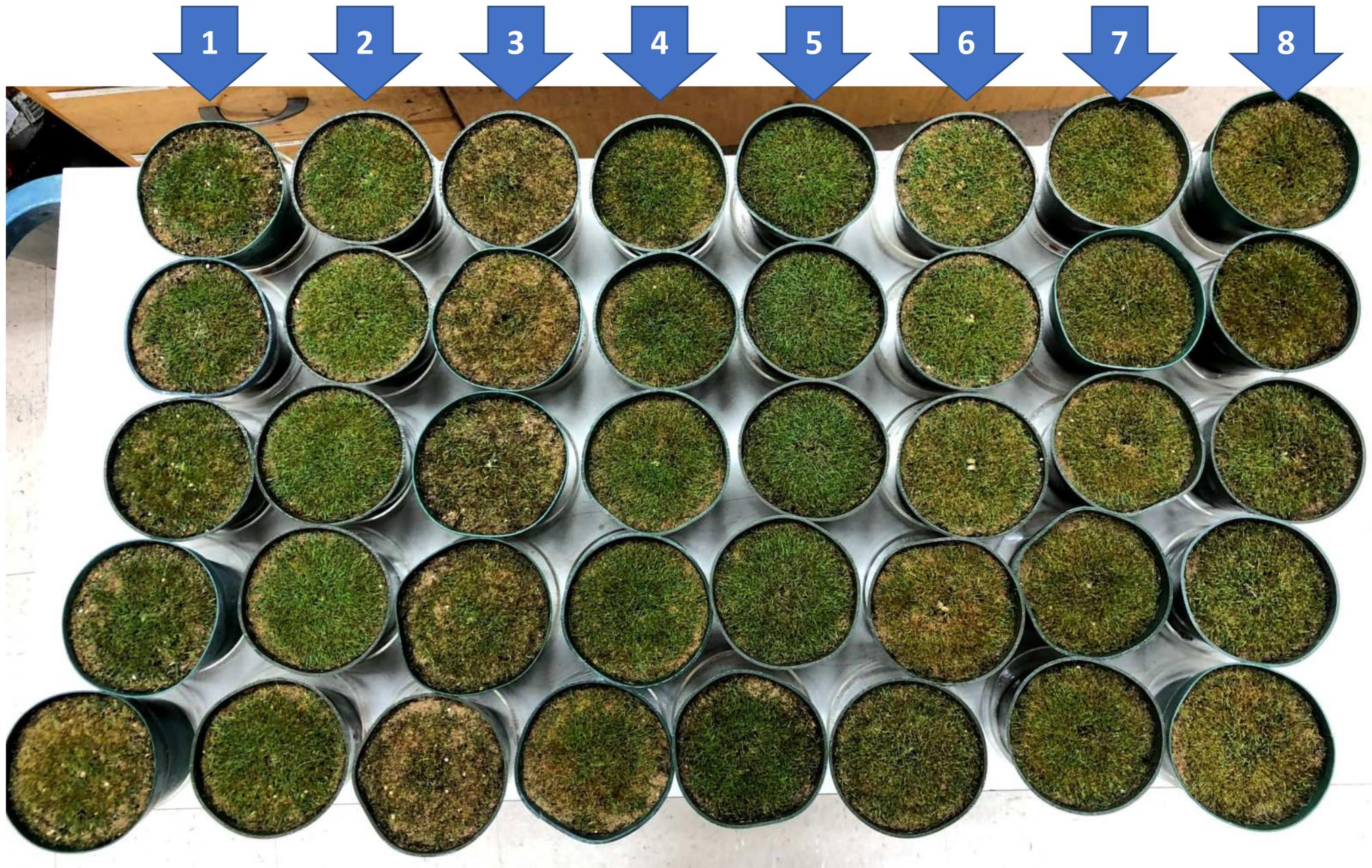


- **Golf course**
2 high
2 low



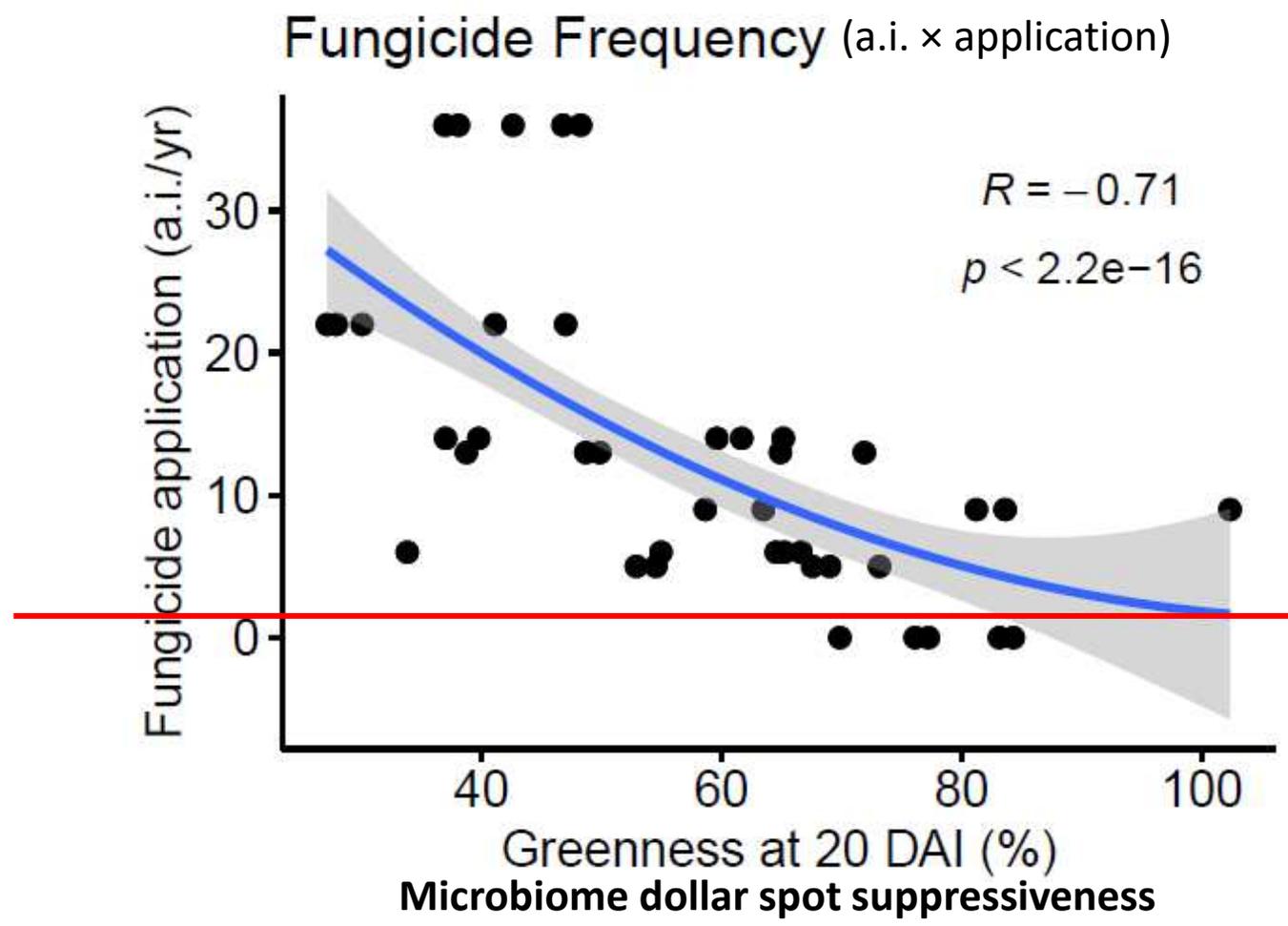
Testing the microbiome disease suppressiveness





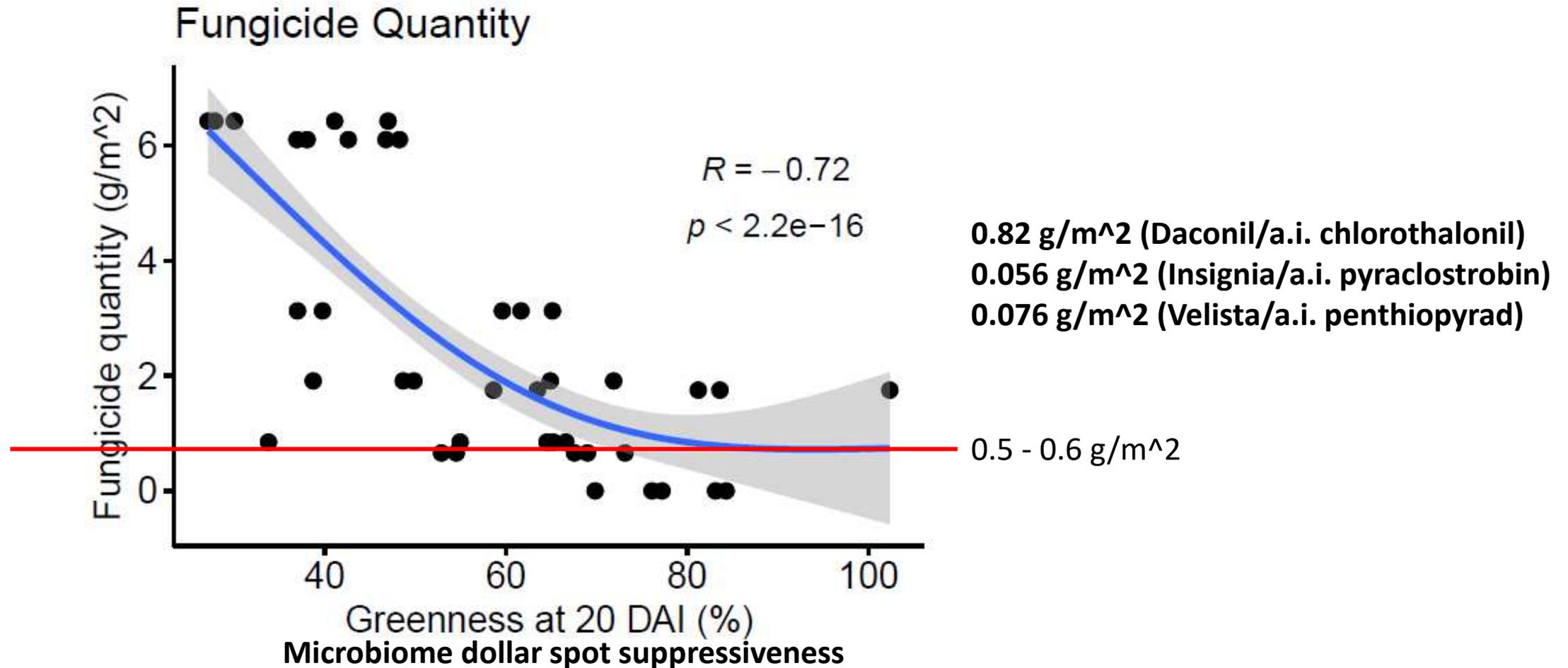


Disease suppression is correlated with fungicide use

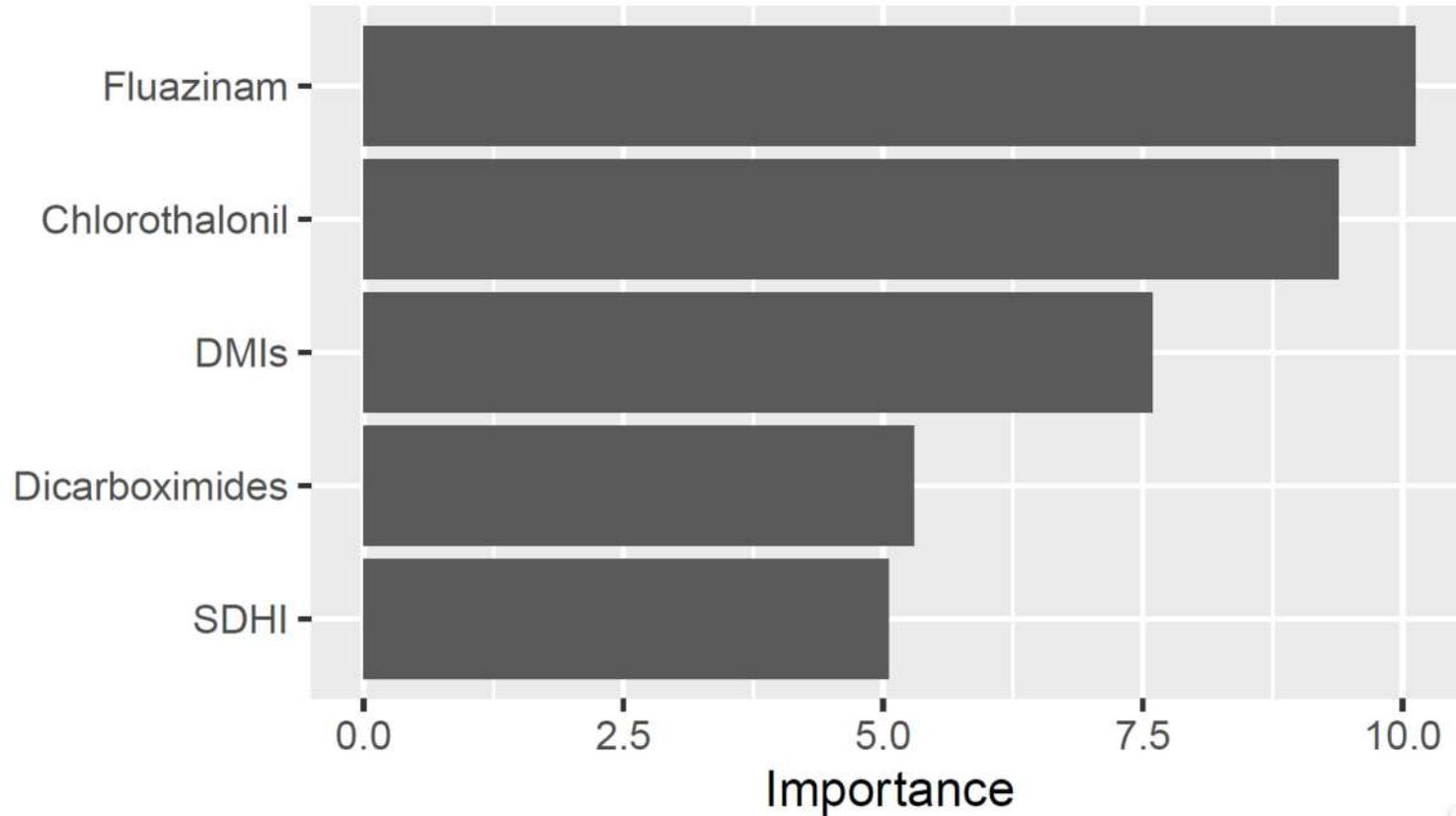




Disease suppression is correlated with fungicide use



Fungicide selection matters



This is a mathematical model and not biologically validated

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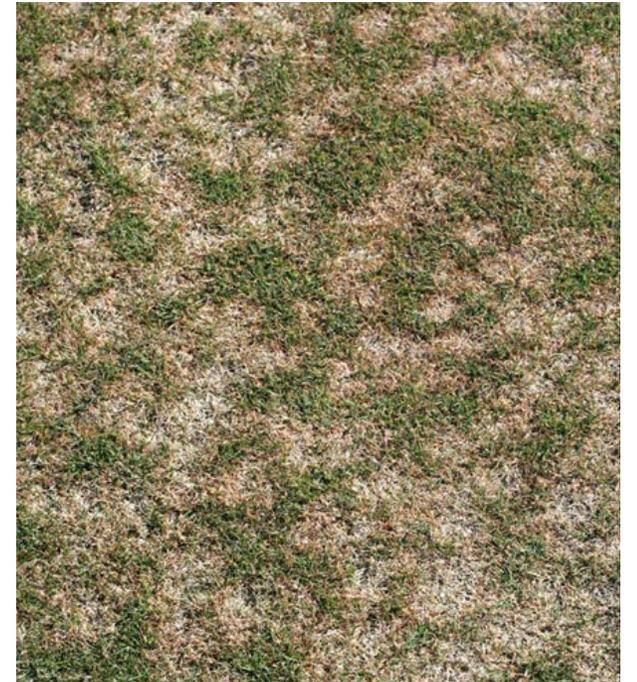
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In the case of diseases outbreak...

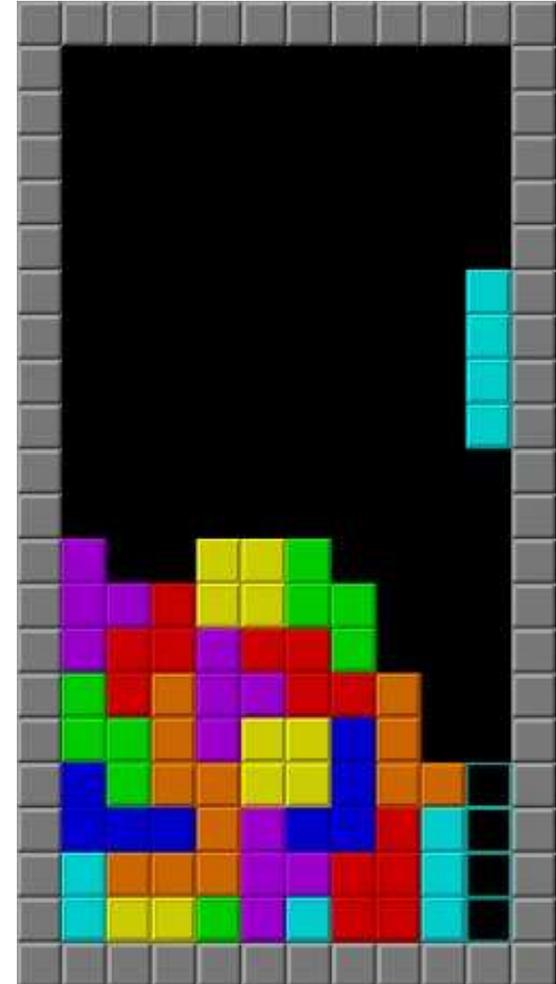


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Principles for effective and sustainable use of fungicides

- Plant health and cultural practices!!!
- Knowing your diseases and timing
- Preventative (early foliar curative) application
- Fungicide selection
- Fungicide class rotation



Fungicide Selection Matters

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;

13. Leaf Spots and Melting Out

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy*	Interval (days)
azoxystrobin: Heritage	11	3.5	14-21
<i>Bacillus amyloliquefaciens</i> , strain PTA-4838: Zorda	BM02	L	7
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-10
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	3	14
fludioxonil: Medallion, Pendant	12	3.5	14-21
fluxastrobin: Fame, Floxcor	11	3	14-21
fluxapyroxad: Xzemplar	7	3	14-28
hydrogen dioxide: Zeritol	NC	L	7
iprodione: Chipco 26GT, Fungicide X, Raven, 18 Plus, Iprodione Pro	2	3.5	14-28
mancozeb: Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	M3	3.5	7-14
mefentrifluconazole: Maxtima	3	3.5	14
mineral oil: Civitas	NC	L ^b	14
myclobutanil: Eagle	3	1	14
PCNB: PCNB, Penstar, Terraclor, Turfcide, Revere	14	2	21-28
penthiopyrad: Velistar	7	3.5	14
polyoxin D: Affirm	19	3	7-14
propiconazole: Banner Maxx, Spectator, Savvi	3	1.5	14
pyraclostrobin: Insignia Intrinsic	11	3	14-28
thiophanate-methyl: 3336 EG, Systec 1998, Cavalier, T-Storm	1	1	7-14
trifloxystrobin: Compass	11	2.5	14-28

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

UK Cooperative Extension Service

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New Jersey Agricultural Experiment Station

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MADISON



Fungicide Selection Matters

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	2	+++	Low			
fluindapyr + flutriafol (Kalida)	0.25 to 0.4	14 to 21	+++	Low	7/3	triadimefon (Bayleton)	1 to 2	21 to 28	++	Low	3
fluopyram + prothioconazole + propamocarb (Resilia)*	4	14 to 28	++++	Low	7/3/28	trifloxystrobin + triadimefon (Tartan)	2	28	+++	Low	11/3
fluxapyroxad + pyraclostrobin (Lexicon)	0.34 to 0.47	14 to 28	+++	Low	7/11						



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

13. Leaf Spots and Melting Out

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy*	Interval (days)
azoxystrobin: Heritage	11	3.5	14-21
<i>Bacillus amyloliquefaciens</i> , strain PTA-4838: Zorda	BM02	L	7
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-10
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	3	14
fludioxonil: Medallion, Pendant	12	3.5	14-21
fluoxastrobin: Fame, Floxcor	11	3	14-21
fluxapyroxad: Xzemplar	7	3	14-28
hydrogen dioxide: Zerotol	NC	L	7
iprodione: Chipco 26GT, Fungicide X, Raven, 18 Plus, Iprodione Pro	2	3.5	14-28
mancozeb: Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	M3	3.5	7-14
mefentrifluconazole: Maxtima	3	3.5	14
mineral oil: Civitas	NC	L ^b	14
myclobutanil: Eagle	3	1	14
PCNB: PCNB, Penstar, Terraclor, Turfcide, Revere	14	2	21-28
penthiopyrad: Velista	7	3.5	14
polyoxin D: Affirm	19	3	7-14
propiconazole: Banner Maxx, Spectator, Savvi	3	1.5	14
pyraclostrobin: Insignia Intrinsic	11	3	14-28
thiophanate-methyl: 3336 EG, Systec 1998, Cavalier, T-Storm	1	1	7-14
trifloxystrobin: Compass	11	2.5	14-28

Efficacy
\$ cost
Environmental cost

7. Dollar Spot

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy*	Interval (days)
<i>Bacillus amyloliquefaciens</i> , strain QST713: Rhapsody, Serenade, Sonnet;	BM02	2	7-10
<i>B. amyloliquefaciens</i> , strain PTA-4838: Zorda			
boscalid: Emerald, Cadence, Ruby	7	1 ^c /4/3.5 ^b	14-28
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-14
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	4	14
fluoxastrobin: Fame, Floxcor	11	3	14-21
flutriafol: Rayora	3	3	14-21
fluxapyroxad: Xzemplar	7	1 ^c /4	14-28
hydrogen dioxide: Zerotol	NC	1	7
iprodione: Chipco 26GT, Raven, 18 Plus, Iprodione Pro	2	3.5	14-28
isofetamid: Kabuto	7	1 ^c /3.5	14
laminarin: Vacciplant	P4	L	7-14
mancozeb: Fore, Protect T/O, Dithane, Mancozeb	M3	1	7-14
mandestrobin: Pinpoint	11	4/3.5 ^b	14-21
mefentrifluconazole: Maxtima	3	4	14-28
metconazole: Tourney	3	4	14-21
mineral oil: Civitas	NC	2 ^d	7-21
myclobutanil: Eagle	3	3	14-28
neem oil: Trilogy	BM01	L	7-14
PCNB: PCNB, Penstar, Terraclor, Turfcide, Revere	14	2 ^e	21-28
penthiopyrad: Velista	7	2 ^c /3.5	14-21
propiconazole: Banner Maxx, Spectator, Savvi	3	4	7-28
prothioconazole: Densicor, Prothioconazole Select	3	4	14-21
pydiflumetofen: Posterity	7	2 ^c /4/3.5 ^b	14-28
pyraclostrobin: Insignia Intrinsic	11	3.5	14
<i>Reynoutria sachalinensis</i> : Regalia PTO	P5	1.5	7-14
<i>Streptomyces lydicus</i> , strain WYEC 108: Actinovate	BM02	L ^f	7-24
tebuconazole: Torque, Mirage Stressgard, Clearscape ETQ, Offset, TEB360	3	4	14-28
thiophanate-methyl: 3336 EG, Fungo, Systemic Fungicide, Systec 1998, Cavalier, T-Storm	1	1 ^c /4	10-21
thiram: Spotrete, Thiram	M3	1	7-10
triadimefon: Bayleton, Fungicide VII	3	4	14-30
<i>Trichoderma harzianum</i> Rifai T-22 plus <i>T. virens</i> G14: RootShield PLUS	NC	1 ^f	14-28
triticonazole: Premis	3	3.5	14-28

Contact; multiple-site:

Chlorothalonil
Fluazinam

Single-site:

DMI
Mefentrifluconazole
Qol
Fluoxastrobin
Pyraclostrobin
SDHI
Fluxapyroxad
Penthiopyrad

2. Anthracnose

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy [*]	Interval (days)
azoxystrobin: Heritage	11	1/3 ^b	14-28
<i>Bacillus amyloliquefaciens</i> , strain QST713: Rhapsody, Sonnet; <i>B. amyloliquefaciens</i> , strain PTA-4838: Zorda	BM02	1.5	7-10
benzovindiflupyr: Instrata II B (only sold in Canada)	7	3	14
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-14
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	1.5	14
fludioxonil: Medallion, Pendant	12	3	14
fluxastrobin: Fame, Floxcor	11	1/3 ^b	14-28
flutriafol: Rayora	3	3	14-21
fosetyl-AI: Chipco Signature, Signature Xtra Stressgard	33	NA ^c	14
hydrogen dioxide: Zerotol	NC	L	7
iprodione: Chipco 26 GT	2	NA ^c	Unspecified
laminarin: Vacciplant	P4	L	7-14
mefentrifluconazole: Maxtima	3	4	14
metconazole: Tourney	3	3	14-21
mineral oil: Civitas	NC	3 ^d	7-14
myclobutanil: Eagle	3	2	14-21
PCNB: Autilus	14	3 ^d	7-10
penthiopyrad: Velist	7	3 ^e	14
phosphite (salts of phosphorous acid): Alude, Apear, Fiata Stressgard, Magellan, Biophos, Resyst, Title Phyte, PK-Plus	33	2 to 3 ^f	14
polyoxin D: Affirm	19	3	7-14
propiconazole: Banner, Spectator, Savvi	3	2.5	14-28
prothioconazole: Densicor, Prothioconazole Select	3	3.5	14-21
pyraclostrobin: Insignia Intrinsic	11	1/3 ^b	14-28
<i>Reynoutria sachalinensis</i> : Regalia PTO	P5	1	7-14
tebuconazole: Torque, Mirage Stressgard, Clearscape ETQ, Offset, TEB360	3	3	14-28
thiophanate-methyl: 3336 EG, Fungo, Systemic Fungicide, Systec 1998, Cavalier, T-Storm	1	1/2 ^b	10-14
triadimefon: Bayleton, Fungicide VII	3	1.5	14-45
trifloxystrobin: Compass	11	1/3 ^b	14-21
triticonazole: Premis	3	3	14-28

4. Brown Patch (Rhizoctonia Blight)

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy [*]	Interval (days)
azoxystrobin: Heritage	11	4/3 ^b	14/28
<i>Bacillus amyloliquefaciens</i> , strain QST713: Rhapsody, Sonnet; <i>B. amyloliquefaciens</i> , strain PTA-4838: Zorda	BM02	1	7-10
chloroneb: Terraneb SP	14	L	10
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-14
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	4	14
fludioxonil: Medallion, Pendant	12	3	7-14
fluxastrobin: Fame, Floxcor	11	3.5	14-28
flutolanil: Prostar, Pedigree	7	3	14-21
flutriafol: Rayora	3	3	14-21
fluxapyroxad: Xzemplar	7	3.5	14-21
hydrogen dioxide: Zerotol	NC	1	7
iprodione: Chipco 26GT, Fungicide X, Raven, 18 Plus, Iprodione Pro	2	3	14-28
mancozeb: Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	M3	3	7
mandestrobin: Pinpoint	11	1.5	14
metconazole: Tourney	3	3	14-21
mineral oil: Civitas	NC	2.5 ^c	14-21
myclobutanil: Eagle	3	2.5	10-21
neem oil: Trilogy	BM01	L	7-14
PCNB: PCNB, Penstar, Terraclor, Turfcide, Revere	14	2 ^d	7-10
penthiopyrad: Velist	7	4	14-21
polyoxin D: Affirm	19	3.5	7-14
propiconazole: Banner Maxx, Spectator, Savvi	3	3	10-21
prothioconazole: Densicor, Prothioconazole Select	3	3.5/3 ^b	14-21
pyraclostrobin: Insignia Intrinsic	11	4	14-28
<i>Reynoutria sachalinensis</i> : Regalia PTO	P5	1	7-14
<i>Streptomyces lydicus</i> , strain WYEC 108	BM02	L ^e	7-24
tebuconazole: Torque, Mirage Stressgard, Clearscape ETQ, Offset, TEB360	3	3	14-28
thiophanate-methyl: 3336 EG, Fungo, Systemic Fungicide, Systec 1998, Cavalier, T-Storm	1	2.5	10-14
thiram: Spotrete, Thiram	M3	2	7-10
triadimefon: Bayleton, Fungicide VII	3	2	14-30
<i>Trichoderma asperellum</i> strain ICC 012 plus <i>T. gamsii</i> strain ICC 080: Obtego	BM02	L ^e	14-28
<i>Trichoderma harzianum</i> strain Rifai T-22 plus <i>T. virens</i> strain G14: TurfShield PLUS	BM02	L ^e	14-28
trifloxystrobin: Compass	11	4	14-21

7. Dollar Spot

Fungicide: Some Trade Names	FRAC Code ^a	Efficacy [*]	Interval (days)
<i>Bacillus amyloliquefaciens</i> , strain QST713: Rhapsody, Serenade, Sonnet; <i>B. amyloliquefaciens</i> , strain PTA-4838: Zorda	BM02	2	7-10
boscalid: Emerald, Cadence, Ruby	7	1 ^c /4/3.5 ^b	14-28
chlorothalonil: Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	M5	3	7-14
fluazinam: Secure, Rotator, Soteria, Downforce ETQ, Flex-guard, Wingspan	29	4	14
fluxastrobin: Fame, Floxcor	11	3	14-21
flutriafol: Rayora	3	3	14-21
fluxapyroxad: Xzemplar	7	1 ^c /4	14-28
hydrogen dioxide: Zerotol	NC	1	7
iprodione: Chipco 26GT, Raven, 18 Plus, Iprodione Pro	2	3.5	14-28
isofetamid: Kabuto	7	1 ^c /3.5	14
laminarin: Vacciplant	P4	L	7-14
mancozeb: Fore, Protect T/O, Dithane, Mancozeb	M3	1	7-14
mandestrobin: Pinpoint	11	4/3.5 ^b	14-21
mefentrifluconazole: Maxtima	3	4	14-28
metconazole: Tourney	3	4	14-21
mineral oil: Civitas	NC	2 ^d	7-21
myclobutanil: Eagle	3	3	14-28
neem oil: Trilogy	BM01	L	7-14
PCNB: PCNB, Penstar, Terraclor, Turfcide, Revere	14	2 ^e	21-28
penthiopyrad: Velist	7	2 ^c /3.5	14-21
propiconazole: Banner Maxx, Spectator, Savvi	3	4	7-28
prothioconazole: Densicor, Prothioconazole Select	3	4	14-21
pydiflumetofen: Posterity	7	2 ^c /4/3.5 ^b	14-28
pyraclostrobin: Insignia Intrinsic	11	3.5	14
<i>Reynoutria sachalinensis</i> : Regalia PTO	P5	1.5	7-14
<i>Streptomyces lydicus</i> , strain WYEC 108: Actinovate	BM02	L ^f	7-24
tebuconazole: Torque, Mirage Stressgard, Clearscape ETQ, Offset, TEB360	3	4	14-28
thiophanate-methyl: 3336 EG, Fungo, Systemic Fungicide, Systec 1998, Cavalier, T-Storm	1	1 ^c /4	10-21
thiram: Spotrete, Thiram	M3	1	7-10
triadimefon: Bayleton, Fungicide VII	3	4	14-30
<i>Trichoderma harzianum</i> Rifai T-22 plus <i>T. virens</i> G14: RootShield PLUS	NC	1 ^f	14-28
triticonazole: Premis	3	3.5	14-28

Considerations for Fungicide Selection

Contact; multiple-site:

Chlorothalonil

Single-site:

DMI

Flutriafol

Metconazole

Prothioconazole

Tebuconazole

QoI

Fluoxastrobin

Pyraclostrobin

SDHI

Penthiopyrad

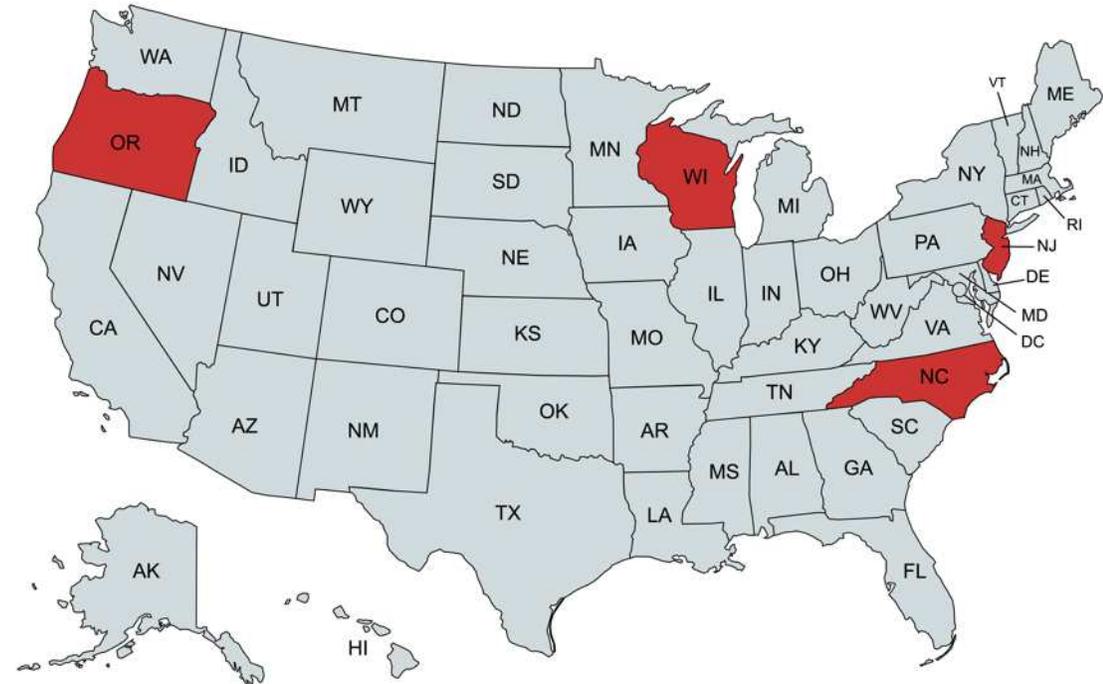
Efficacy

\$ cost

Environmental cost

Fungicide Efficacy Evaluation Process

- Develop a testing protocol
- Universities send out a 'call for protocols', what the diseases will be, what the cost is, etc
- Companies respond with the products they want to test, diseases they want to test on, etc
- Universities often specialize in certain diseases



Major collaborators





RUTGERS

New Jersey Agricultural Experiment Station
Center for Turfgrass Science

Fungicide efficacy evaluation program



Photo by Ming-Yi Chou



RUTGERS

New Jersey Agricultural Experiment Station
Center for Turfgrass Science

Fungicide efficacy evaluation program



Photo by Ming-Yi Chou



RUTGERS

New Jersey Agricultural Experiment Station
Center for Turfgrass Science

We evaluated ~500 treatments each year



Fungicide efficacy evaluation program



Biological Fungicide Will Only Get Better in The Future

Table 2. Fungicides in use up until 1940 [after Russell 2005 (15)]



Year	Fungicide	Primary Use
1637	Brine	Cereal seed treatment
1755	Arsenic	Cereal seed treatment
1760	Copper sulfate	Cereal seed treatment
1824	Sulfur (dust)	Powdery mildew and other pathogens
1833	Lime sulfur	Broad spectrum foliar pathogens
1885	Bordeaux mixture	Broad spectrum foliar pathogens
1891	Mercury chloride	Turf fungicide
1900	CuOCl ₂	Especially <i>Phytophthora infestans</i>
1914	Phenylmercury chloride	Cereal seed treatment
1932	Cu ₂ O	Seed and broad spectrum foliar diseases
1934	Dithiocarbamates patented	Broad spectrum protectants
1940	Chloranil, Dichlone	Broad spectrum seed treatment

1970s First commercial plant disease biocontrol product
Galltrol (*Agrobacterium radiobacter*)

2000s Rhapsody (*B. amyloliquifaciens*, former *B. subtilis*)

What's next?

Outline

- What is microbiome?
- What are the functions of microbiome?
- Can we enrich the beneficial microbes?
- Can we cultivate healthy microbiome?
- Considerations for chemical control
- Final thoughts





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 spot, brown patch, pythium – under “disease/stress risk” tab

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)

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Lab news

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

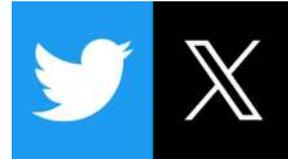
[Open Postdoc Position in Turfgrass Pathogen Population Genetics and Microbiome](#)
January 9, 2025

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



<https://sites.rutgers.edu/chou-lab/resources/>

Thank you for listening



@TurfgrassChou
mingyi.chou@rutgers.edu