

NOTE: THE FOLLOWING INFORMATION IS OFFERED AS A GUIDE FOR PROSPECTIVE CHALLENGES TO MANAGING SEASHORE PASPALUM. ALL TURFGRASSES ARE SUBJECTED TO INSECT, DISEASE, AND WEED PRESSURES. PROPER MANAGEMENT IS THE KEY TO SUCCESS. YOU MUST CHECK ALL LABELS OF THE PESTICIDES TO BE USED ON THIS GRASS FOR LEGAL AND PROPER USE. MENTION OF A PARTICULAR PRODUCT IS NOT AN ENDORSEMENT OF THAT PRODUCT BUT REFLECTS WHAT IS KNOWN AT THE PRESENT TIME. ENVIRONMENTAL INTERACTIONS, INCLUDING SALINITY THAT IMPACT SPECIFIC SITES, MAY GIVE VARIABLE RESULTS IN THE USE OF SOME PRODUCTS.

ROTATING FUNGICIDE CHEMISTRIES: DEVELOPMENT OF RESISTANT TURFGRASS DISEASE PATHOTYPES

Fungi that attack turfgrasses have a tendency to mutate and create a fungicide-specific resistant pathotype when one mode-of-action chemistry is repeatedly applied to the turf ecosystem. Rotating the fungicide chemistry by applying different mode-of-action products and by combining two or more different MOA products is a good management strategy to minimize the development of resistant pathotypes.

Application of fungicides that require more than one gene mutation to form resistant pathotypes, such as the multisite inhibitors, is also a good strategy to include in your disease management program.

Multisite Inhibitors (takes more than one mutation to create resistant pathotypes)

chlorothalonyl (Daconil, Previa)

mancozeb (Fore)

thiram (Spotrete, Tersan, Defiant)

fluazinam (Secure, Rotator, Sipcam Agro, Downforce ETQ, Soteria, Flex-Guard)

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Rotating the single site inhibitors among different MOA chemistries is an essential strategy to minimizing the development of fungicide-resistant pathotypes:

Single site inhibitors (one gene mutation and repeated applications can potentially create a new resistant pathotype)

1. Benzimidazole

thiophanate methyl (Cleary's 3336)

2. DMIs (sterol demethylation inhibitors)

metaconazole (Tourney)

flutriafol (Rayora)

myclobutanil (Eagle)

propiconazole (Banner Maxx)

tebuconazole (Torque, Mirage)

triadimefon (Bayleton)

triticonazole (Triton, Trinity)

fenarimol (Rubigan)

cyproconazole (Alto)

defenoconazole (Inspire)

mefentrifluconazole (Revysol)

prothioconazole (Densicor)

PGRs flurprimidol (Cutless) and paclobutrazol (Trimmit) have potential DMI activity.

3. QOL (quinone outside inhibitor)

azosystrobin (Heritage)

fluoxastrobin (Fame, Disarm)

pyraclostrobin (Insignia)

trifloxystrobin (Compass)

mandestrobin (Pinpoint)

4. QIL (quinone inside inhibitor)

cyazofamid (Segway)

5. SDHI (succinate dehydrogenase inhibitors)

flutolanil (Prostar, Pedigree)

boscalid (Emerald)

penthiopyrad (Velistar)

fluxayroxad (Xzemplar)

fluopyram (Exteris, Indemnify nematocide)

isofetamid (Kabuto)

pydiflumetofen (Posterity)

fluindapyr

6. Dicarboximides

iprodione (Chipco 26GT)

vinclozolin (Curalan, Touche)

7. Acylpicolides

fluopicolide (Stellar)

8. Carboximides

boscalid (Emerald)

9. Phenylamides

mefenoxsam (Apron, Ridomil, Subdue)

10. Phenylpyrrole

fludioxonil (Medallion)

11. Phosphonates

forsetyl-al (Alliette, Signature)

potassium phosphonate/phosphite (alude, Apear, Magellan, Vital)

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Known Development of Fungicide Resistant Pathotypes

Dollar Spot: avoid/minimize application of single chemistry benzimidazoles, DMIs, dicarboximide, SDHI

Microdochium patch: avoid/minimize dicarboximides

Pythium blight: avoid/minimize QOLs, phenylamides

Grey leaf spot: avoid/minimize QOLS

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The list below provides information on combining different MOA and different fungicide chemistries for controlling diseases. Aeration events will be needed when attempting to control or suppress the soil borne fungi in order to provide a conduit to move sufficient concentrations of the fungicide down below the soil surface for effective disease control.

DUAL CHEMISTRY AND/OR DUAL MODE-OF-ACTION FUNGICIDES

azoxystrobin + cyazofamid (Union)

azoxystrobin + difenoconazole (Briskway)

azoxystrobin + propiconazole (Headway, Quilt)

azoxystrobin + chlorothalonil (Renown)

azoxystrobin + cyproconazole (Quadris Xtra)

azoxystrobin + tebuconazole (Armour Tech ZOXY-T, Strobe-T, Oximus)

azoxystrobin + propiconazole + difenconazole + Solatenol (Contend)

boscalid + pyraclostrobin (Honor Intrinsic)

chlorothalonil + thiophanate-methyl (Consyst, Peregrine, Spectro)

chlorothalonil + propiconazole (Concert)

chlorothalonil + fludioxonil + propiconazole (Instrata)

chlorothalonil + tebuconazole (E-Scape ETQ)

chlorothalonil + thiophanate-methyl + tebuconazole (Enclave)

chlorothalonil + triticonazole (Reserve)

chlorothalonil + fenarimol (Lesco Twosome)

chlorothalonil + potassium phosphite (Vitalonil)

chlorothalonil + boscalid (Encartis)
copper hydroxide + mancozeb (Junction)
difenoconazole + fludioxonil (Instrata Elite)
difenoconazole + benzovindiflupyr (Acernity)
fluindapyr (SDHI) + flutriafol (new DMI) {Kalida}
fludioxonil + mefenoxam (Apron Maxx)
fluopicolide + propamocarb hydrochloride (Stellar)
fluopyram + trifloxystrobin (Exteris Stressgard)
fluxapyroxad + pyraclostrobin (Lexicon)
fluazinam + tebuconazole (Traction, Fairview Select)
fluoxastrobin + chlorothalonil (Disarm C, Fame C)
fluoxastrobin + myclobutanil (Disarm M)
fluoxastrobin + tebuconazole (Fame T)
flutolanil + thiophanate-methyl (Systar)
iprodione + trifloxystrobin (Interface)
iprodione + thiophanate-methyl (Chipco 26/36, Dovetail)
isofetamid + tebuconazole (Tekken)
myclobutanil + mancozeb (MANhandle)
PCNB + propiconazole + chlorothalonil (FF III)
PCNB + tebuconazole (Premion, Oreon)
pyraclostrobin + triticonazole (Pillar G)
thiophanate-methyl + mancozeb (Duosan)
thiophanate-methyl + thiram (Bromosan)
triadimefon + thiram (Proturf Fluid Fungicide)

triadimefon + flutolanil (Prostar Plus)

triadimefon + trifloxystrobin (Armada, Tartan)

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Literature

Rick Latin. June 2021. Combination fungicides for improved disease control. Golf Course Management (gcmonline.06.21). Pages 70-72.

Rick Latin 2021. A practical guide to turfgrass fungicides. APS Press, St. Paul, MN.

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Some fungicide chemistries are sensitive to acidic, alkaline, and muddy water quality conditions and adjustments in the water quality will be needed to provide effective fungicide efficacy for disease control.

Fungicide x Water Quality Interaction on Chemical Efficacy

Fungicide	<u>Water Quality</u>		
	Acidic	Alkaline	<u>Muddy</u>
	<u>(pH<6)</u>	<u>(pH>8.0)</u>	
Azoxystrobin	ok	dnu	nr
Chlorothalonil	ok	ok	tfc
Ethazole	ok	ok	tfc
Fenarimol	ok	ok	ok
Fosetyl Al	ok	ok	dnu
Mancozeb	nr	nr	tfc
Mefenoxam	ok	tfc	tfc
PCNB	ok	tfc	nr

Propiconazole	ok	ok	tfc
Thiophanate methyl	tfc	dnu	tfc
Trifloxystrobin	tfc	tfc	nr

Dnu=do not use; tfc=test for compatibility; nr=not recommended

Source: D.Park and J-H. 'J.C.'Chong. 2010. Carrier water quality and pesticide stability. Golf Course Industry 22(11):37-39.

FUNGICIDE EFFECTS ON SOIL MYCORRHIZAE

A mycorrhiza is a symbiotic association between a fungus and the turfgrass root. The arbuscular fungi can colonize the roots of the turfgrass plant either intracellularly (endomycorrhiza) or extracellularly (ectomycorrhiza) involving a mutualistic association of carbohydrate supply exuded from the roots and the roots utilizing the larger surface area of the fungal mycelium to absorb water and mineral nutrients (especially phosphorus) from the soil.

Endomycorrhiza

These fungi are classified as arbuscular (vesicular-arbuscular or VAM) are mycorrhizas whose hyphae enter turfgrass root cells, producing either balloon-like vesicles or dichotomously-branching invaginations or arbuscules. These fungal hyphae do not penetrate the protoplast interior part of the cell, but invaginate the cell membrane, increasing the contact surface area between the hypha and the cell cytoplasm to facilitate nutrient exchange.

Ectomycorrhiza

These EcM fungi have a hyphal sheath or mantle that covers the root cap or a net of hyphae that surround the plant cells within the turfgrass root cortex.

Outside the root, the fungal mycelium forms a comprehensive network encompassing the soil particles and organic components. Occasionally, these fungi may penetrate the plant cells and are called ectendomycorrhiza when that invasion occurs.

<u>Common Name</u>	<u>Trade Name</u>	<u>Endomycorrhiza</u>	<u>Ectomycorrhiza</u>
Azoxystrobin	Heritage	N	N
Banrot	Banrot	U	S
Chlorothalonil	Bravo, Daconil	N	L
benodamil, triadimefon	Bayleton	S	S
captan	Captan, Orthocide	S	L
chloroneb	Terraneb, Terremec	L	S
zinc ethylene	Maneb, Mancozeb	N	S
bisdithiocarbamate	Manzate, Fore, Formec, Wingman, Dithane		
etridiazole	Koban	U	S
fenarimol	Rubigan	N	U
flutolanil	Prostar	U	U
forsetyl-Al	Aliete, Prodigy	N	N
iprodione	Chipco 26019	N	U
metalaxyl-ridomyl	Apron, Subdue	L	N
myclobutanil	Eagle, Siskin	U	U
propamocarb	Banol, Banner Maxx	S	U
quintozone	PCNB, Terrachlor	L	S
	Turfcide		
streptomycin	Agri-Step	U	U
thiophanate-methyl	Cleary's 3336	N	U
	Systec 1998		
Thiram	Tersan	N	S

Thiazole	Benomyl, Benlate	S	L
	Tersan		
Vinclozolin	Curlan, Vorlan	U	U
zinc white	Zinc oxide	U	S

N=no effect L=no effect at low rate; tends to suppress at high rate

S=suppresses at any rate U=unknown

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New Enhancement Chemical Additive Products:

Rhapsody (biofungicide derived from *Bacillus subtilus* QST713 and can be tank mixed with chlorothalonil fungicides)

Spot-Less (microbial biofungicide derived from *Pseudomonas aurofaciens* strain TX-1)

Actinovate SP/ActinoGrow™ (microbial biofungicide derived from *Streptomyces lydicus* strain WYEC108)

EcoGuard (microbial biofungicide derived from *Bacillus licheniformis* strain SB3086)

Companion® (microbial biofungicide derived from *Bacillus subtilus* strain GB03; antibiotic is Iturin); apply when soil temperatures are above 45°F (7°C) and/or prior to early light frost. Turns on plant induced systemic resistance mechanisms. Acts as a plant growth promoting rhizobacterium.

Micro-Blaze® (synergistic blend of *Bacillus* spores and proprietary wetting agent + nitrogen and phosphates; probiotic technology)

-----*Bacillus licheniformis* strain SB308G

-----*Paenibacillus elgii* SD17 (for pythium and soil borne pathogens)

ArmorTech® Sonnet (United Turf Alliance) (biorational fungicide with *Bacillus subtilis* strain QST713)

PC1 food grade emulsifiers + isoparaffins (for anthracnose, dollar spot)

Subtilex NG (Becker Underwood) *Bacillus subtilis* strain MBI600

Sinc (fungicide activator)

Civitas (synthetic isoparaffin-based product that primes the turfgrass genes to stimulate natural defenses and inhibit pathogenic fungi via induced systemic resistance stimulation or plant defense activation)

Regalia PTO biofungicide (*Reynoutria sachalinensis* extract; induced systemic mode of action); Syngenta and Engage Agro

Endorse (Arysta Lifescience) (polyoxin D from actinomycete)

Acibenzolar-s-methyl (ACTION) products (i.e. Heritage & Daconil Action)

***NOTE: these biofungicides or enhancement additives can be combined with normal reduced volume fungicides to provide a synergistic interaction for preventative disease control.**

Inoculaid®/Quantum (photosynthetic *Rhodospirillum* (Rs.) spp. purple sulfur bacteria)—caution: do not use on greens (this product thrives in anaerobic micro-environments); generally not recommended in turfgrass ecosystems.

REFERENCE

IRAC Mode of Action Classification Scheme. December 2018. Version 9.1. www.irac-online.org. 30 pages.