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Chemical Control of Turfgrass Diseases 2009

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Turfgrasses under intensive management are often subject to outbreaks of infectious diseases. Diseases usually are most damaging when weather or cultural conditions favor the disease-causing agent but not plant growth and vigor. Cultural conditions that enhance turfgrass diseases include close mowing, inadequate or excessive nitrogen fertility, light and frequent irrigations, excessive thatch, poor drainage, and shade.

Good turf management practices often greatly reduce the impact of diseases by promoting healthy plants that are better able to resist infections. Even under good management, however, diseases sometimes cause excessive damage to highly managed turfgrasses. The proper use of fungicides in these instances, in conjunction with good cultural practices that promote quality turf, can be an important part of an overall disease management program.

Fungicides available for controlling turfgrass diseases in Kentucky are listed in Tables 1 and 2. Specific application rates, safety precautions, and other important information are provided on the labels of the formulated products. *Read these labels carefully and completely before using fungicides.*

Diseases in Home Lawns

This publication is intended for professional turfgrass managers who use fungicides as part of an overall disease control program. Homeowners with diseased lawns should obtain a copy of the University of Kentucky Cooperative Extension publication *Disease Management in the Home Lawn* (ID-105), available at your county Extension office or on the Web at www.ca.uky.edu/agc/pubs/id/id105/id105.htm.

ID-105 describes cultural practices that usually can alleviate infectious diseases in home lawns without the use of fungicides. Consider these limitations before using commercial fungicides:

- they are effective only against specific turfgrass diseases,
- they must be applied at the right time to be effective, and
- they often must be applied repeatedly.

For these reasons, fungicide use by homeowners is generally discouraged. Certain fungicides labeled for disease control may not be used in residential lawns; see product labels for such restrictions.

Because of Food Quality Protection Act considerations, chlorothalonil, iprodione, and vinclozolin are no longer labeled for use in home lawns.

Contact and Systemic Fungicides

There are two general types of fungicides. *Contact fungicides*, sometimes called *protectant fungicides*, remain on the plant surfaces after application and do not penetrate the plant tissue. *Systemic fungicides* are those that are absorbed into the plant. Some systemic fungicides move within the plant very little from the site of penetration; these are called *locally systemic*. The dicarboximide fungicides are one example of this group. Some locally systemic fungicides simply cross the leaf blade from one leaf surface to the other but do not redistribute within the plant. In that case, these are called *translaminar fungicides*; trifloxystrobin is an example. Some systemic fungicides move within the water-conducting tissue (xylem), which takes them upward in the transpiration stream; downward mobility within the plant is very limited. These are called *xylem-mobile systemics*. Within this group, some fungicides are moderately mobile within plants, such as certain DMI fungicides. Others are highly mobile and move readily through the xylem. Examples of highly xylem-mobile systemics include thiophanate-methyl and mefanoxam. A third type of systemic fungicide is the *phloem-mobile systemic*, which moves bidirectionally (from leaves to roots and vice versa). Only one example of this type of systemic exists among turfgrass fungicides: fosetyl-Al.

Systemic fungicides sometimes can suppress the fungus after it has infected the plant, whereas contact fungicides must be present on the plant's surfaces before infection begins in order to be effective.

Preventive versus Curative Use

Fungicide labels usually provide a range of application rates and intervals. Fungicides can be used on a *preventive* basis (usually at low rates and/or at long intervals between applications) when a disease outbreak has not yet occurred but when weather favorable for disease is expected. Conversely, fungicides may be used on a *curative* basis (often at higher rates and/or at short intervals) after an outbreak has occurred and disease pressure is high. Curative applications cannot cause sick tissues (yellow or brown leaves, rotted roots) to become healthy again. Curative applications can simply protect uninfected tissues and new growth and are only effective if the turf is actively growing.

Fungicide Resistance

Infectious fungi sometimes develop resistance to particular fungicides, especially when a product is used repeatedly without alternating to chemically unrelated fungicides and without reducing disease pressure through cultural practices. When fungicide resistance develops, use of that product or other chemically similar products no longer controls the disease effectively. The risk of fungicide resistance is especially great for a number of systemic fungicides. In Kentucky, fungicide resistance has been confirmed in numerous instances for each of the following diseases and fungicide groups: anthracnose to QoI (= strobilurin) fungicides and to thiophanate-methyl; dollar spot to thiophanate-methyl and/or DMI fungicides; gray leaf spot to QoI

(= strobilurin) fungicides; and Pythium blight to phenylamide fungicides. In addition to these cases, examples reported from other states include resistance to benzimidazole fungicides in pink snow mold and resistance to QoI (= strobilurin) fungicides in Pythium blight. All systemic fungicides have some risk for the development of resistance, but certain groups of fungicides are more at risk than others. Currently available contact fungicides have essentially no risk of resistance. The relative risk of resistance among the various fungicide families is noted in Table 1.

Several general strategies are recommended to minimize the risk of fungicide resistance. Understand that these general principles can reduce but not eliminate risk. A fungicide-resistant pathogen population can still develop in swards where these principles are practiced.

Table 1. Fungicidal and selected biological materials for turf disease control.

Fungicide	FRAC Code[a]	Fungicide Group[b]	Risk of Resistance	Mobility[c]	Some Product Names
azoxystrobin	11	QoI (= strobilurin)	high	XMS	Heritage
Bacillus licheniformis	Not listed	Biocontrol agent	low	C	EcoGuard
Bacillus subtilis, strain QST 713	Not listed	Biocontrol agent	low	C	Rhapsody
boscalid	7	Carboximide	moderate	XMS	Emerald
captan	M4	Phthalimide	NS[d]	C	Captan
chloroneb	14	MA	low to NS	C	Terraneb SP, Proturf Fungicide V
chlorothalonil	M5	Chloronitrile	NS	C	Daconil, Echo, Manicure, Chlorostar, Concorde SST, Pegasus L
cyazofamid	21	Cyanoimidazole	unknown	C	Segway
ethazole (= etridiazole)	14	Triadiazole	NS	C	Koban, Terrazole
fenarimol	3	DMI	moderate	XMS	Rubigan AS
fludioxonil	12	Phenylpyrolle	moderate	C	Medallion
fluoxastrobin	11	QoI (= strobilurin)	high	XMS	Disarm
fluopicolide	43	Benzamide	moderate	LS	Stellar (a premix with propamocarb)
flutolanil	7	Carboximide	moderate	XMS	Prostar
fosetyl-Al	33	Phosphonate	low	PMS	Chipco Signature, Prodigy
hydrogen dioxide	Not listed	Oxidizing agent	low	SC	Zerotol
iprodione	2	Dicarboximide	moderate	LS	Chipco 26019, Chipco 26GT, Proturf Fungicide X, Iprodione Pro, Raven
mancozeb	M3	EBDC	NS	C	Fore, Manzate 200, Protect T/O, Mancozeb, Dithane, Formec, Pentathlon
mefenoxam	4	Phenylamide	high	XMS	Subdue MAXX, Quell, Mefanoxam, Fenox
metalaxyl	4	Phenylamide	high	XMS	Subdue 2E, Proturf Pythium Control, Apron seed treatment
metconazole	3	DMI	moderate	XMS	Tourney
myclobutanil	3	DMI	moderate	XMS	Eagle, Golden Eagle
PCNB (= pentachloronitro-benzene; or = quintozene)	14	MA	low to NS	C	Defend, Penstar, Terraclor, Turfcide, Revere
phosphite (salts of phosphorous acid)	33	Phosphonate	low	PMS	Magellan, Biophos, Resyst, Alude, Vital
polyoxin D zinc salt	19	Polyoxin	moderate	LS	Endorse
propamocarb	28	Carbamate	moderate	LS	Banol, Stellar (a premix with fluopicolide)
propiconazole	3	DMI	moderate	XMS	Banner MAXX, Propiconazole Pro, Spectator, Savvi
pyraclostrobin	11	QoI (= strobilurin)	high	LS	Insignia
thiophanate-methyl	1	MBC	high	XMS	Cleary's 3336 Plus, Allban, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, Absorb TM, T-Storm, Tee-Off
thiram	M3	Dithiocarbamate	NS	C	Spotrete, Thiram, Defiant
triadimefon	3	DMI	moderate	XMS	Bayleton, Proturf Fungicide VII
Trichoderma harzianum	Not listed	Biocontrol agent	low	C	Bio-Trek, Turfshield, TurfMate
trifloxystrobin	11	QoI (= strobilurin)	high	LS	Compass
triticonazole	3	DMI	moderate	XMS	Trinity, Triton
vinclozolin	2	Dicarboximide	moderate	LS	Curalan, Touché, Vorlan

[a] FRAC codes indicate the biochemical target site of action, according to the Fungicide Resistance Action Committee. M3, M4, and M5 indicate multisite inhibitor, with no significant risk of resistance.
[b] DMI = demethylation inhibitor; EBDC = ethylene bis-dithiocarbamate; MA = miscellaneous aromatic; MBC = methyl benzimidazole carbamate.
[c] C = contact (= protectant) fungicide; LS = locally systemic; XMS = xylem-mobile systemic; PMS = phloem-mobile systemic; SC = surface contact (no residue remains on leaf surface).
[d] NS = not significant.

1. Do not rely on fungicides alone for disease control: avoid using turfgrass varieties that are highly susceptible to common diseases, and use cultural disease management practices to reduce selection pressure on the fungus to develop resistance.
2. Limit the number of times that at-risk fungicides are used during a growing season. Alternate at-risk fungicides with products from different fungicide groups.
3. When using an at-risk fungicide, tank-mixing it with a fungicide having another biochemical target site can also reduce the risk of resistance buildup (but refer to fungicide labels before tank-mixing to ensure compatibility and to avoid phytotoxicity).
4. Be sure to use proper nozzles and adequate gallonage, especially when tank-mixing a contact fungicide with an at-risk fungicide, to assure thorough coverage of all plant surfaces with the contact.
5. Use of below-label rates can speed selection of resistant strains with certain types of fungicides. Thus, use tank-mixes at below-label rates only for mixtures known to be synergistic. (*Synergism* means that disease control from the fungicide mixture is better than expected. An analogy is when one plus one equals three instead of two.) *Diseases of Turfgrasses, Third Edition* by Houston Couch lists fungicide mixtures with demonstrated synergism.

FRAC codes (and the fungicide groups generally represented by these) are indicated for all fungicides listed in Table 1. This information allows turfgrass managers to rotate among (or tank-mix) fungicides having different biochemical target sites. Simply choose among products that do not share the same FRAC code. FRAC codes for each fungicide are determined by the Fungicide Resistance Action Committee, a worldwide consortium of scientists representing fungicide manufacturers; the codes are available at www.frac.info/frac.html. Before tank-mixing pesticides, refer to product labels to ensure compatibility and to prevent phytotoxicity.

Prepackaged Fungicide Mixtures

Several products formulated for turf disease control are prepackaged mixtures containing two or more active ingredients. Some examples of prepackaged mixtures are listed in Table 2. Mixtures provide some protection against fungicide resistance and typically provide a broader spectrum of activity against turfgrass diseases. Also, improved disease control (called synergism) sometimes occurs with mixtures of fungicides. Prepackaged mixtures offer convenience and assurance against incompatibility. However, *be aware that the efficacy ratings reported in this publication are based on application rates indicated on the labels of the individual active ingredients, not prepackaged mixtures.* This is important because application rate of an active ingredient in a prepackaged mixture may not be as high as the rate when that same active ingredient is formulated alone.

Table 2. Prepackaged fungicide mixtures.

Active Ingredients	Some Product Names
azoxystrobin + propiconazole	Headway
chlorothalonil, fludioxonil + propiconazole	Instrata
copper hydroxide + mancozeb	Junction
fenarimol + chlorothalonil	Lesco Twosome
iprodione + thiophanate-methyl	Proturf Fluid Fungicide
metalaxyl + triadimefon	Proturf Fluid Fungicide II
myclobutanil + mancozeb	MANhandle
thiophanate-methyl + chloroneb	Proturf Fungicide IX
thiophanate-methyl + chlorothalonil	ConSyst, Spectro, Broadcide, Peregrine
thiophanate-methyl + flutolanil	SysStar
thiophanate-methyl + mancozeb	Duosan
thiophanate-methyl + thiram	Bromosan
triadimefon + thiram	Proturf Fluid Fungicide III
triadimefon + flutolanil	Prostar Plus
trifloxystrobin + triadimefon	Armada, Tartan

Fungicide Tank Mixes for Putting Greens

Tank-mixing on-site offers greater flexibility in fungicide choice and application rates than prepackaged mixtures. Because the number of possible tank-mixes among fungicidal products is vast, this publication does not provide an exhaustive discussion of these. However, several tank-mixes deserve mention because of the substantial base of published research on field performance of these on putting greens. Tank-mixes of the products referred to below have been thoroughly tested. However, for other tank-mixes, be sure to refer to product labels before tank-mixing to ensure compatibility and to avoid phytotoxicity.

DMI/Chlorothalonil Tank-Mixes for Late Spring through Early Autumn

Preventive applications of a DMI fungicide at low to moderate levels of its labeled rates mixed with chlorothalonil at its low to moderate labeled rates have consistently provided excellent control of dollar spot, anthracnose, red leaf spot, and copper spot on putting greens. For brown patch, such mixtures have provided very good to excellent control in most instances. However, for the period of July through mid-August, brown patch control should be enhanced by increasing the rate of chlorothalonil or by using another product with high efficacy against that disease. Typically these sprays should be begun before Memorial Day and applied every two weeks for best results. Stretching the spray interval much beyond two weeks can result in loss of efficacy, and it can also enhance the risk of buildup of DMI-resistant pathogen populations.

As a specific example, Banner MAXX 1.24MEC at 0.5 to 1.0 fl oz plus Daconil Ultrex 82.5WDG at 1.8 to 3.2 oz can be applied biweekly for broad-spectrum control of the diseases mentioned. In sites with high pressure from brown patch, the 3.2-oz rate of Daconil Ultrex is advisable during hot, humid weather. Where anthracnose is the primary target disease, a rate of 2.75 oz of Daconil Ultrex would be recommended based on the label, although we have often achieved excellent control using a lower rate in the tank-mix.

The advantages of the DMI/chlorothalonil tank-mix include:

- more consistent performance against a variety of diseases than the individual products,
- an acceptable fungicide-resistance management strategy,
- greatly reduced concern over undesirable growth-regulating effects of DMI fungicides when these are used at high rates during summer, and
- control of algae.

Superintendents will still need a separate control program for Pythium cottony blight, and they are advised to avoid using chlorothalonil during periods when the green is under acute drought stress.

Tank-Mixes of Fosetyl-Al with Chlorothalonil or Iprodione for Summer Stress

Biweekly applications of fosetyl-Al mixed with either chlorothalonil or iprodione have consistently provided excellent control of dollar spot, anthracnose, and brown patch on putting greens. For example, a biweekly rotation of two tank-mixes—Chipco Signature 80WG at 4 oz plus Chipco 26GT 2SC at 4 fl oz followed by Chipco Signature 80WG at 4 oz plus Daconil Ultrex 82.5WDG at 3.2 oz—has consistently provided good to excellent control of the diseases mentioned above. Such a spray program also provides reasonably good protection against Pythium cottony blight, and it helps reduce application frequency of chlorothalonil. In addition to disease control, these tank-mixes have been shown to help maintain turfgrass quality of creeping bentgrass putting greens during certain conditions of stressful weather in summer. Turfgrass quality of *Poa annua* and bermudagrass has also been improved with these mixes. The basis for this enhanced turfgrass quality has not been clearly established, but it appears to be due to enhanced physiological vigor of the turfgrass rather than control of subclinical infections of roots and crowns by facultative saprophytes like *Rhizoctonia solani* and *Pythium* species. It has been suggested that the dye or other inert ingredients in the formulation of Chipco Signature may be partly responsible for this improved turf quality. There is evidence to suggest that optimal protection against environmental stress will be obtained when at least two sequential applications have been made.

Mixtures of fosetyl-Al with either chlorothalonil or iprodione provide acceptable control of red leaf spot under low disease pressure (which is typical of most putting greens) but not under high disease pressure. Based on research at the University of Kentucky, the tank-mix containing chlorothalonil would be expected to be effective against copper spot but not the tank-mix containing iprodione. Mixtures of fosetyl-Al with mancozeb have also been tested thoroughly but have not consistently provided acceptable control of dollar spot or brown patch.

Iprodione/Chlorothalonil Mixtures for Pink Snow Mold

PCNB has proven to be an outstanding fungicide for controlling pink snow mold (also known as Microdochium patch or Fusarium patch when it occurs during rainy weather instead of under snow cover). However, application of PCNB has been shown to cause notable phytotoxicity to certain cultivars of creeping bentgrass and to *Poa annua* under some conditions. Superintendents can expect a similar level of disease control without the risk of phytotoxicity from a mixture of iprodione and chlorothalonil, each at their labeled rates. Indeed, the tank-mix often provides a greater level of disease control than either product alone. Although gray snow mold is rarely a problem in Kentucky, this mixture also controls that disease, should it occur.

Fungicide Efficacy

Fungicides labeled for control of specific turfgrass diseases are listed under each disease discussed in this publication. The relative effectiveness of these fungicides is also provided. For each disease, labeled fungicides are given an efficacy rating from 1 to 4 based on relative effectiveness. Efficacy ratings were assigned by reviewing the performance of these fungicides in at least 775 research reports published over a 32-year period in *Fungicide and Nematicide Tests* and *Plant Disease Management Reports*, published by the American Phytopathological Society. These reports are available on the Web at www.apsnet.org.

Many reports from other sources were also evaluated. Experimental results were evaluated only when products were used in a manner similar to current label directions. For each disease, results from numerous scientifically acceptable experiments were used in assigning ratings, although results from experiments conducted in Kentucky were given higher weight than other results.

Be aware that disease-control products are marketed to turfgrass managers even though published information showing effective control is lacking from recognized scientific publications. Pesticide manufacturers are not required by law to demonstrate effective control of the disease listed on the label. Considering this, it seems wise to select from among disease-control products shown to be effective in published reports.

Revisiting Fungicide Synergism

Pesticide *synergism* is the phenomenon whereby a combination of two pesticides gives better control than would be expected by simply summing the control levels provided by the individual pesticides. Synergism is analogous to "1+1=3." In cases of *additivity*, the combination works better than the individual pesticides but only as well as would be predicted by summing the pest control provided by the individual pesticides (1+1=2). And, of course, there is *antagonism*, which is when the combination of pesticides performs more poorly than would be expected by summing the pest control provided by the individual pesticides (1+1=1). Careful and thorough testing is required to demonstrate synergism, additivity, or antagonism, although funding for such tests is very hard to come by. Consequently, few research programs have done this kind of work.

For many years, the only in-depth source of information on such possible interactions among fungicides in turf has been Dr. Houston Couch's excellent and comprehensive reference, *Diseases of Turfgrasses, Third Edition.* Recent well-conducted field research in Georgia and Indiana indicates, however, that the fungicide combinations reported in *Diseases of Turfgrasses* to be synergistic against dollar spot perform disappointingly. In this research, out of a total of 108 separate evaluations (fungicide mixture x assessment date) of dollar spot, only three were synergistic.

Recent research does not negate the value of mixing fungicides. Fungicides in mixtures usually do act additively, and mixing fungicides helps to reduce the risk of fungicide resistance. But the latest research raises questions as to the consistency of fungicide synergism (1+1=3) for disease control under field conditions.

Nontarget Effects of Fungicides

Wise turf managers always recognize that fungicides and other pesticides can have unexpected consequences on the turf ecosystem or the environment. Consider the possibility of nontarget effects when evaluating the need for fungicide applications. It should be noted that these nontarget effects are isolated events that are, except for phytotoxicity, usually less important than management of the disease for which the fungicides were intended. However, they serve as a reminder to avoid unnecessary fungicide use when possible.

Phytotoxicity and Turf Growth Regulation

Commercial fungicide products generally have been exhaustively tested by the time they are marketed and rarely cause injury to turfgrasses. In unusual circumstances, certain formulations of some active ingredients can cause temporary yellowing or browning, usually with no lasting effects on the turf. An effort has been made to note these possibilities in this publication.

As a class, the DMI fungicides can exhibit growth-regulating effects on turfgrass through inhibition of gibberellic acid synthesis. These fungicides sometimes produce a desirable darker green color on turfgrass. Undesirable effects sometimes include a coarser appearance through a widening of leaf blades, color changes (such as yellowing, a bluish appearance, bronzing or browning of turf), and reduced growth rate. Research has clearly shown that putting-green turf exhibiting growth-regulating effects of DMI fungicides can suffer significantly greater infestations of algae in summer. Growth-regulating effects of DMI fungicides generally are associated with high use rates and/or repeated applications, particularly on turf under stress from high temperatures or drought.

During hot summer months, use DMI fungicides on putting greens at low rates. Care should be taken when using both DMI fungicides and certain plant growth regulators (PGRs) on putting greens, especially paclobutrazol and flurprimidol. The possible additive effect of these similar chemistries can cause significant turf growth suppression and discoloration. This is most evident in bentgrass putting greens that have many segregated colonies of bentgrass and/or *Poa annua* genotypes.

Thatch Accumulation

Several fungicides (thiophanate-methyl, iprodione, mancozeb, and thiram) have been found to enhance thatch accumulation in turf under intensive management. Benzimidazole fungicides are toxic to earthworms, and because earthworms play an important role in thatch decomposition, benzimidazole fungicides can encourage thatch to accumulate. All of these fungicides can have an important place in a turf disease management program, but one should avoid exclusive use of these products at high rates.

Reductions of Seedling Establishment

Research is limited on the effects of fungicides on establishment of seedlings in the absence of disease. However, in several field studies, fenarimol applied immediately prior to seeding reduced seedling vigor of roughstalk bluegrass (*Poa trivialis*).

Disease Enhancement or Resurgence

Many fungicides are selectively toxic to certain groups of fungi. These often do an excellent job of controlling the target fungal disease but in some instances can cause increased pressure from another fungal disease normally not controlled by the product. One important example of this disease enhancement in Kentucky is enhancement of summer patch by applications of chlorothalonil. As another example, dollar spot can be enhanced by azoxystrobin or flutolanil. The mechanisms of disease enhancement are often not well understood for any given case. However, possible mechanisms include suppression of antagonistic microorganisms naturally present in the turf ecosystem and enhanced physiological stress on turf already under water stress from root disease. Field research in Kentucky and elsewhere has documented instances of *disease resurgence* following fungicide application. This means that the target disease was controlled during the period of fungicide effectiveness but then became more severe than in untreated plots after the fungicide weathered away.

Pesticide Contamination of Surface Water by Runoff

Usually, the amounts of pesticides applied to turf that move off-target in runoff is low to insignificant. This is because mature turfgrass swards provide a dense perennial vegetation cover that favors water retention. However, turf areas that receive intensive pesticide applications can, under certain circumstances, be sources of environmental contamination by runoff. As an example, the fungicide chlorothalonil (in Daconil and many other products) is highly toxic to fish, aquatic invertebrates, mollusks, and shrimp. Because of these facts and the heavy use of this fungicide on turfgrass, the U.S. Environmental Protection Agency imposed restrictions on chlorothalonil use in turfgrass and other crops in order to reduce the risk of disruption to aquatic ecosystems. Be sure to heed restrictions on the chlorothalonil label as to the maximum rate allowable and the number of applications that can be made each season. Widespread abuse of the restrictions on chlorothalonil could put the registration of that fungicide at risk.

Be aware of potential risks to the quality of surface waters whenever pesticides are applied. To reduce the risk of water contamination in runoff, consider the following recommendations:

- Apply pesticides to turf only; avoid application on non-turf surfaces (driveways, sidewalks, etc.).
- Use care when applying pesticides to saturated soil, frozen soil, or prior to a forecast of heavy rainfall.
- If irrigating following pesticide application, be sure not to apply irrigation at a rate that exceeds the infiltration rate of the soil.
- Use care when applying pesticides during the early phase of a grow-in because the incomplete soil coverage by vegetation permits greater amounts of runoff.
- Maintain unsprayed vegetation as filter strips along streams, ponds, lakes, and sinkholes. These can range from turf mowed at 3 inches or higher to unmowed tall fescue sod to attractive native vegetation and wildflowers. In addition to serving as filter strips, certain types of vegetation can also provide wildlife habitat.
- Do not apply in wind, and use nozzles designed to reduce spray drift to nontarget areas.

Pesticide Breakdown at High pH

Pesticides are generally most stable when the pH in the spray tank ranges from 4 to 6. Certain pesticides can chemically decompose quickly at pH above 7.0; this phenomenon is called *alkaline hydrolysis*. If a pesticide is subject to alkaline hydrolysis, leaving the product in a spray tank with high-pH water for several hours or overnight can result in substantial or complete loss of pesticide efficacy. In the most extreme case, a certain insecticide (trichlorfon, in Dylox) is known to have a half-life of just a few minutes at pH 8.0 but a half-life of 3.7 days at pH 6.0. Alkaline hydrolysis is a concern with the fungicides polyoxin D and thiophanate-methyl; other fungicides listed in Table 1 may also be subject to alkaline hydrolysis. Check the pH of the water you use to mix pesticides, and check with technical representatives to see if the products you are using are subject to alkaline hydrolysis. If so, consider adding a buffering agent to the spray tank, especially in cases where the entire tankful will not be completely sprayed immediately.

Formulation

Several fungicidal products are available in more than one formulation. For contact fungicides, a sprayable formulation (wettable powder, flowable, dry flowable, water-dispersible granule, emulsifiable concentrate) usually provides better control of foliar diseases than a granular formulation. Sprayable formulations can be superior to granular formulations even for systemics that are not highly mobile in plant tissues, such as certain DMI fungicides. Spray equipment allows more thorough coverage of plant surfaces than does a granular spreader. More thorough coverage can result in better control of fungi that infect foliage. If granular fungicides are being used for foliar disease control, their effectiveness can be improved by applying to wet leaves. Do not mow, and collect clippings immediately after application.

If fungicide sprays are being applied to control a root disease, it is often advisable to lightly irrigate before the fungicide dries in order to wash it into the root zone. Likewise, if granulars are being applied to control root diseases, apply to dry turf and irrigate after application.

Reducing Summertime Stress on Putting Greens

Since numerous infectious agents can be more damaging when putting-green turf is stressed, the following agronomic practices can be an important component of disease management during summertime.

- Raise mowing height if possible. An increase of as little as 0.0313 inch to 0.0625 inch often can help. Reducing mowing frequency and increasing rolling frequency may also be useful practices during stress periods. According to recent research at Cornell University, a potential loss of quality and green speed due to reduced mowing frequency can be offset by frequent rolling with triplex-mounted rollers. Use mowers with smooth instead of grooved rollers and with sharp reels. Skip mowing every third or fourth day or even more frequently if the green is so stressed that it is not growing rapidly. Minimize cleanup passes, mowing them even less frequently. Use lightweight walk-behind mowers on stressed greens if possible, especially on the cleanup pass. Once stressful conditions slow turf growth, disengage or remove grooming devices such as brushes and verticutters. Avoid mowing when greens are waterlogged, especially during hot weather, since the mower will sink into the turf, resulting in scalping.
- Take care to avoid root-zone saturation. This will improve soil oxygen levels and reduce heat conduction into the root zone; it will also speed cooling of the root zone at night. Under high temperatures, overwatering is more detrimental than a water deficit because it prevents roots from absorbing oxygen. When irrigation is needed, apply water by hand to avoid overirrigating, irrigating only collars and elevated areas of the green if possible. Hand-irrigate known dry spots prior to wilting. If roots are shallow, irrigate only to the depth of the roots.
- Minimize leaf wetness caused by dew. Irrigation applied around sunrise can reduce the duration of leaf wetness periods. Also mowing or poling during early morning hours can be very beneficial.
- For improved root-zone aeration and cooling, spike the greens regularly with needle tines to keep the surface from sealing, use water-injection aerification, or aerify with solid tines or 0.25-inch hollow tines. If aerifying, leaving aerification holes open allows for better gas exchange but may lead to desiccation during dry, windy conditions. On greens with a serious buildup of organic matter in the top 2 inches, a program of nondisruptive cultivation (spiking or water-injection aerification) at three-week intervals beginning in early summer can help maintain oxygen in the root zone, thus reducing the detrimental impact of a sudden onset of hot weather. On hot days, syringe during the afternoon to reduce heat stress, applying water to the foliage only. Instead of using the irrigation system, use a nozzle that produces a fine mist so as to avoid applying water to the root zone if the soil is nearly saturated. Systems that force air movement through the root zone of the green can improve turf health during summer by removing CO_2 and excess water from the root zone (thereby increasing oxygen content), as well as possibly lowering soil temperatures. These should be monitored carefully in order to avoid removing too much water and increasing localized dry spot.
- During extended periods of unusually wet summer weather, consider spiking or light aerification at regular intervals in order to improve drying and oxygen diffusion in the root zone. If aerifying, solid, star, or cross-tines are preferable. Hollow-tine aerification using small (0.25-inch) tines to a depth of 1 inch or less can also help. However, be sure to blow cores off the green since dragging cores may excessively injure the turf at that time of year. Be aware that greens with very shallow roots may be disrupted by the mechanical action of the aerifier. During the heat of summer, perform these operations during evening hours to reduce stress on the turf. Prior to mowing, a light rolling the morning after aerification will reduce the risk of scalping around raised aerification holes.
- Use foliar applications of soluble nitrogen at rates of 0.125 to 0.25 lb N/1000 sq ft every 10 to 14 days. Avoid fertilization rates exceeding 0.25 lb of quick-release N/1000 sq ft in

a single application; this can encourage excessive growth of disease-susceptible foliage and diminish root reserves. For a darker green color, apply 2 oz/1000 sq ft of iron sulfate or 3 oz/1000 sq ft of iron chelate. While some nitrogen is necessary for turf growth and recovery from stress, high rates in summer can enhance disease activity.

- Curtail topdressing, or use a light rate once a week that does not require brushing. When topdressing at other times of the year, use sand with some angularity for stability under foot traffic. Verticutting should be curtailed during periods of heat stress, and topdress no more often than every two to three weeks during normal summer weather.
- Use spikeless shoes. Rotate hole locations frequently to minimize traffic injury.
- Where air circulation is inadequate, selectively prune or remove trees and underbrush, or install fans. Fans should be monitored carefully in order to avoid excessive drying and increasing localized dry spot.
- Use fungicides judiciously since several contacts and systemics have some potential for phytotoxicity or growth regulation. Avoid applications of pesticides when the temperature exceeds 85°F unless a serious disease or pest problem (such as Pythium blight) threatens the health of the turf.
- Minimize use of herbicides during heat stress periods. Some oil-based and ester-based formulations of herbicides can cause turfgrass injury.
- In cases where roots have deteriorated (brown and/or short roots), whether from infectious disease or noninfectious stress, raise height of cut by 0.0625 inch or more, and possibly remove grooved rollers in order to reduce stress. Since the turf has an extremely limited root system, irrigate lightly and frequently to provide sufficient water for growth and reduce wilting. Hand-watering affected areas is advisable if possible so that the unaffected portions of the green do not become overwatered. Lightly spiking the greens will help improve aeration and surface sealing—usually caused by algae or moss. But consider this only if the daily temperatures are not in the 90s. Since roots are damaged and will take up nutrients in the soil very poorly, fertilize every week or two with a foliar nitrogen product that provides from 0.125 to 0.25 lb of actual N/1000 sq ft.

Useful Web Resources

Web-based resources that may prove useful to readers include the following:

- University of Kentucky Turfgrass Science Program (http://www.uky.edu/Ag/ukturf/)
- Identification of turfgrass species (http://www.agry.purdue.edu/turf/tool/index.html)
- Disease identification (http://extension.missouri.edu/explore/agguides/pests/ipm1029.htm)
- Online calculator for calibration of equipment for application of liquid pesticides (http://floridaturf.com/bermuda/spraycal.htm)
- National Turfgrass Evaluation Program (http://www.ntep.org/)

Algae *(not a true disease)*

Pathogen: Various terrestrial blue-green and green algae

Principal Turfgrass Hosts: Creeping bentgrass, *Poa annua*

Season: May-October

Comments: Algae on greens may indicate overwatering, poor drainage, and/or shady conditions. Decrease shade and increase air circulation around greens. Allow the surfaces to dry completely between irrigation events. Avoid irrigation in late afternoon or in evening prior to midnight. Spike greens and topdress every three to four weeks to promote surface drying. Alleviate compaction. Control diseases and other stresses that lead to an open turfgrass canopy. Use fungicides only in conjunction with good water management. Preventive applications are superior to curative applications. Follow label recommendations regarding gallonage; addition of surfactants is not recommended. DMI fungicides can sometimes enhance algal infestation through growth regulation that causes an opening of the turf canopy. This is most likely when DMI fungicides are applied at high rates during periods with temperatures above 85°F, especially when other stresses are present. In one putting-green experiment, an organic nitrogen source favored algal development, whereas inorganic nitrogen did not. Copper hydroxide has the potential to cause phytotoxicity (yellowing or necrosis of foliage tips) on cool-season grasses, especially on *Poa* species. Conditions that enhance phytotoxicity from copper hydroxide include hot conditions, low pH of spray solution (as happens when the product is tank-mixed with certain products like Chipco Signature or products containing thiophanate-methyl), or tank-mixing with herbicides. Also, repeated use of copper hydroxide at high rates will lead to copper buildup in the soil; this creates a potential risk of phytotoxicity if the soil pH becomes unusually low. Potassium salts of fatty acids may be phytotoxic above 80°F.

Algae		**Efficacy**[1]	**Interval** *(days)*
Fungicide	**Some Product Names**		
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo	3+	7-14
copper hydroxide + mancozeb	Junction	4	7-14
hydrogen dioxide	Zerotol	1	7
mancozeb	Fore, Manzate 200, Protect T/O, Mancozeb, Dithane, Pentathlon	3	7-14
quaternary ammonium compounds	Algaen-X, Consan Triple Action 20, Quickstop	1	7-14
triticonazole	Trinity, Triton	L	14-28

Anthracnose

Pathogen: *Colletotrichum cereale*

Principal Turfgrass Hosts: *Poa annua*, creeping bentgrass

Season: June-September on creeping bentgrass, April-September in *Poa annua*

Comments: On creeping bentgrass, the disease is associated with very warm weather. On bentgrass sites with a history of the disease, begin fungicide applications before Memorial Day, continuing until the end of August. On greens with the basal rot phase of the disease, use walk-behind mowers, and raise the height of cut. Irrigate greens as needed to avoid drought stress.

On *Poa annua* greens, basal anthracnose can develop under a wider range of temperatures than in creeping bentgrass. There are four peak periods of anthracnose development: (1) during cool/moist periods in early spring, and even through winter if conditions are mild and wet; (2) following peak periods of flowering in early summer; (3) during periods of high temperature and humidity; and (4) during periods of extended overcast conditions in late spring. It should also be noted that active anthracnose has been found occasionally under snow cover in late winter in Pennsylvania. During these high-risk periods, minimize practices that cause stress to the plant (discussed below).

Basal anthracnose on *P. annua* appears to be favored by slow percolation of soil water. The combination of excessive soil wetness and heavy traffic can be particularly conducive to disease; therefore, improve drainage, avoid overwatering. A high organic-matter content in the root zone of a sand-based green can hold excessive moisture and may favor infection. If this condition exists, apply one of two treatments in spring and fall: (1) aerify with 0.25-inch to 0.50-inch tines on close spacing (1.25 inches to 1.5 inches) just deeply enough to penetrate the organic layer, then fill with sand; or (2) if heavy organic matter is in the top inch, verticutting to a 1-inch depth will remove organic matter more effectively than aerification but will require longer recovery times. Also, redirect traffic if possible and avoid allowing the turf to wilt, particularly from midday to late afternoon, as that may enhance susceptibility. Shady conditions can also enhance susceptibility. As conditions warrant, begin preventive fungicide applications by mid-April and continue applications into mid-October. Under severe disease pressure, research shows that biweekly fungicide applications may be needed from early April through mid-November. If temperatures are above normal in December through February, begin a preventive program on *Poa annua* in early to mid-March, especially if conditions in early spring are wet. Some studies show enhanced control of basal anthracnose when using DMI fungicides applied in 5 gal water/1000 sq ft, as compared to lower volumes. If the disease has been active, avoid use of turf growth regulators to promote recovery.

For both *Poa annua* and creeping bentgrass, cultural practices that reduce stress may help significantly; see the previous section on "Reducing Summertime Stress on Greens." Be sure to provide sufficient soluble nitrogen to maintain a moderate growth rate through the summer (foliar applications of approximately 0.25 lb soluble N/1000 sq ft every month, applied every 7 days), as low levels of N used to promote increased ball speed can enhance disease severity. Recent studies in Pennsylvania suggest that a foliar nitrogen content of 5% in *Poa annua* reduces susceptibility significantly. Raise the mowing height if possible since studies have shown substantially increased basal rot at lower mowing heights; an increase of 0.020 inch can be significant. Indeed, it may not be possible to control the disease with fungicides on *P. annua* when mowed at or below 0.125 inch. Double-cutting and lightweight vibratory rolling can help maintain acceptable green speed without increasing disease pressure.

Recent research at Rutgers University indicates that anthracnose is *stress-related* but not *wound-related*. Shallow verticutting for grooming purposes (to a depth of 0.1 inch) has not increased anthracnose damage in research trials, although verticutting to a depth that could cause severe wounding of crowns and stolons (0.2 inch) can enhance anthracnose damage. Although light topdressing may temporarily increase disease pressure, in studies thus far, light, frequent topdressing (i.e., 1 cu ft of sand per 1000 sq ft every week) through the summer has

Anthracnose			
Fungicide	**Some Product Names**	**Efficacy[1]**	**Interval** *(days)*
azoxystrobin*	Heritage	3	14-28
Bacillus licheniformis	EcoGuard	L	3-14
Bacillus subtilis, strain QST 713	Rhapsody	L	7-10
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	3	7-14
fenarimol	Rubigan	2	30
fludioxonil	Medallion	2	14
fluoxastrobin	Disarm	3	14-28
fosetyl-Al	Chipco Signature	NA**	14
hydrogen dioxide	Zerotol	L	7
iprodione	Chipco 26 GT	NA**	unspecified
metconazole	Tourney	L	14-21
myclobutanil	Eagle	2	14-21
phosphite (salts of phosphorous acid)	Alude	2 to 3***	14
polyoxin D	Endorse	3	7-14
propiconazole	Banner, Spectator, Savvi	2	14-28
pyraclostrobin	Insignia	3	14-28
thiophanate-methyl*	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm	2	10-14
triadimefon	Bayleton, Proturf Fungicide VII	1+	14-45
trifloxystrobin	Compass	3+	14-21
triticonazole	Trinity, Triton	3	14-28

* Isolates of *C. cereale* resistant to azoxystrobin (and related QoI fungicides) and/or thiophanate-methyl are very common in numerous locations.
** NA = not applicable. The Chipco 26GT and Chipco Signature labels require tank-mixing with selected fungicides for anthracnose control; poor control can be expected from each product when sprayed alone.
*** More effective for controlling anthracnose on *Poa annua* than on creeping bentgrass.

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

been associated with an overall improvement in anthracnose control in mid- to late summer compared to non-topdressed plots. Minimize mowing when the turf is soggy since the equipment will sink into the turf, potentially scalping the turf. Use walk-behind mowers, and reduce mowing frequency if the green is growing slowly. Irrigate to avoid wilting, particularly between midday and late afternoon.

Typically, preventive spray programs have been much more effective than curative programs against this disease. A good guideline is to begin a preventive program approximately one month before the typical onset of symptoms at the site. In numerous studies, preventive applications of fungicide mixtures have provided better control than the single fungicide products used alone. Preventive applications of reduced-rate tank-mixes of a DMI fungicide and chlorothalonil at two-week intervals have provided excellent control in a number of experiments on creeping bentgrass greens. Avoid high rates of DMI fungicides on putting greens during summer because of the possibility of undesirable growth-regulator effects. When using DMI fungicides alone for anthracnose control, apply in 5 gal water/1000 sq ft. For all other fungicides, a minimum spray volume of 2 gal/1000 sq ft coupled with nozzles providing excellent one-pass coverage is recommended. Tank-mixes of fosetyl-Al plus iprodione or chlorothalonil have also been shown to control anthracnose preventively in most tests on creeping bentgrass putting greens during summertime. If curative applications are necessary, they should include chlorothalonil tank-mixed with a systemic for best results; avoid use of chlorothalonil alone since, in one test, this fungicide used alone reduced summertime root length in a creeping bentgrass putting green.

The fungicide flutolanil and the herbicides dithiopyr (Dimension) and bensulide (Betasan) have been shown to enhance damage from anthracnose, as has repeated application of iprodione and vinclozolin used alone. Repeated applications of trinexapac ethyl (Primo) have reduced anthracnose severity in some instances in tests conducted at Rutgers University, possibly by creating more uniform surface less prone to scalping. The use of the growth regulator mefluidide (Embark) alone or ethephon (Proxy) alone has resulted in slight temporary enhancement of anthracnose severity in some instances. However, a program combining mefluidide with regular applications of trinexapac ethyl consistently has resulted in reduced anthracnose, possibly because of the combined stress-reducing effects of reduced flowering (mefluidide) and reduced mowing frequency or reduced scalping (trinexapac ethyl). Likewise, an ethephon application plus sequential applications of trinexapac ethyl has resulted in anthracnose reductions as well. If using mefluidide or ethephon, consider applying an anthracnose fungicide around the same time, and be sure that nitrogen levels are adequate. When using thiophanate-methyl, check the pH of the water used to prepare spray solutions; if the pH is high, include a buffering agent to bring the pH to 7.0 to avoid alkaline hydrolysis.

Although azoxystrobin and other QoI fungicides have performed well in early research trials, the emergence of resistant strains is a concern in Kentucky and nationwide. High levels of resistance to QoI fungicides (FRAC Code 11) and to thiophanate-methyl (FRAC Code 1) have been documented in anthracnose isolates collected from many locations. Because of this, many superintendents should not rely on these fungicide families for anthracnose control; instead, cholorothalonil, fosetyl -Al;, fludioxonil, and polyoxin D will be the best choices for many locations. Note that these materials are best used as preventive rather than curative applications. For courses where QoI fungicides and/or benzimidazole are used, avoid sequential applications of either fungicide family in order to reduce the risk of fungicide resistance. For the same reason, it is advisable, when using these fungicides for anthracnose control, to tank-mix them with a contact fungicide. For sites with multiple resistance to QoI fungicides and thiophanate-methyl, the following combinations can be used, all at 14-day intervals (products with identical active ingredients may be substituted at equivalent rates): Chipco Signature 80WDG 4.0 oz plus Daconil Ultrex 82.5WDG 3.2 oz; Chipco Signature 80WDG 4.0 oz plus Fore Rainshield NT 80WP 8.0 oz; Banner MAXX 1.24MEC 1.0 fl oz plus Daconil Ultrex 82.5WDG 3.2 oz; and Medallion 50WP 0.25 oz plus Daconil Ultrex 82.5WDG 3.2 oz plus Banner Maxx 1.3ME 1.0 fl oz. Reports of quantitative resistance (= reduced sensitivity) to DMI fungicides (FRAC Code 3) have emerged recently as well, though to our knowledge, these resistant strains are not yet widespread. Diagnosis of anthracnose on turf (any species) at fairway height or higher often suggests involvement of a predisposing stress.

Bentgrass/Bermudagrass Dead Spot

Pathogen: *Ophiosphaerella agrostis*

Principal Turfgrass Hosts: Creeping bentgrass, hybrid bermudagrass

Season: May-October (creeping bentgrass), March-May (bermudagrass)

Comments: Only known to occur on sand-based greens and tees, typically on swards less than six years old, or following fumigation. Favored by heat and drought stress. May be confused with dollar spot, copper spot, microdochium patch, black cutworm damage, or ball marks.

Bentgrass/Bermudagrass Dead Spot		**Efficacy**[1]	**Interval** *(days)*
Fungicide	**Some Product Names**		
boscalid	Emerald	L	14
fludioxonil	Medallion	L	14
fosetyl-Al	Chipco Signature	NA*	14
pyraclostrobin	Insignia	4	14-28
thiophanate-methyl	Cleary's 3336 Plus	L	14
* NA = not applicable. The Chipco Signature label requires tank-mixing with selected fungicides for control of bentgrass dead spot; poor control can be expected from fosetyl-Al alone.			

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Brown Patch *(= Rhizoctonia Blight)*

Pathogen: *Rhizoctonia solani, Rhizoctonia zeae*

Principal Turfgrass Hosts: Ryegrasses, tall fescue, and bentgrasses

Season: June-September

Comments: Most severe during warm, humid weather, especially when night temperatures exceed 60°F. Avoid high nitrogen fertility during summer. Periodically aerify and use other practices that promote good soil drainage. Improve air circulation. The use of fans on putting greens with poor air circulation can reduce brown patch pressure dramatically by improving air circulation, reducing soil moisture, shortening periods of leaf wetness, and lowering canopy temperature. On putting greens, start a preventive spray program when low temperatures exceed 60°F for two to three consecutive nights (usually early June in central Kentucky and late May in western Kentucky). During the period from early July through mid-August, when disease pressure typically is highest, use products with good to excellent effectiveness against brown patch. A curative program (rather than a preventive program) during this time of year is discouraged because of the potential for rapid disease development and the low recuperative potential of creeping bentgrass at that time of year.

When curative control is required, consider using azoxystrobin or pyraclostrobin; expect that symptoms may increase for several days after application as previously infected tissues continue to develop symptoms. Applications of PCNB prior to or during hot weather may cause phytotoxicity to creeping bentgrass. Use insecticides and herbicides judiciously during an active outbreak of brown patch as several of these have been shown to increase brown patch activity. Various plant growth regulators (PGRs) used on turfgrasses have been shown to occasionally influence brown patch severity. In particular, applications of Cutless (flurprimidol) have been shown to reduce the efficacy of several DMI fungicides against brown patch. In a University of Kentucky test, Daconil Ultrex caused phytotoxicity on creeping bentgrass under acute drought stress. If using thiophanate-methyl, check the pH of the water used to prepare spray solutions; if the pH is high, include a buffering agent to bring the pH to 7.0 to avoid alkaline hydrolysis.

Avoid high rates of DMI fungicides on putting greens during summer because of the possibility of undesirable growth-regulator effects. Research has shown that putting-green turf exhibiting growth-regulating effects of DMI fungicides can suffer significantly greater infestations of algae in summer. In one putting-green test, use of pyraclostrobin at the high labeled rate led to encroachment by algae. In one test, a fairway tank-mix spray program of Banner MAXX plus Heritage 50WG plus Primo MAXX led to brown patch resurgence approximately one month after applications ended.

For high-maintenance tall fescue lawns, applications of azoxystrobin, flutolanil, or pyraclostrobin have provided acceptable control of brown patch for four to five weeks in several published tests under high disease pressure. Granular formulations of fungicidal materials can provide disease suppression but sometimes do not provide complete disease control.

On several turf species, failures of fungicides that are normally effective against brown patch may indicate the presence of *Rhizoctonia zeae*, which can sometimes be active during very hot conditions. Do not rely on thiophanate-methyl for brown patch control during hot (> 90°F), humid conditions favorable for *R. zeae*. Field studies in South Carolina suggest that azoxystrobin or a combination of chlorothalonil and fosetyl-Al will control *R. zeae*. Certain fine fescue cultivars are reported to be injured by chlorothalonil.

Brown Patch = Rhizoctonia Blight		**Efficacy**[1]	**Interval** *(days)*
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	4/3*	14-28
Bacillus licheniformis	EcoGuard	2	3-14
Bacillus subtilis, strain QST 713	Rhapsody	L	7-10
captan	Captan	L	7-10
chloroneb	Terraneb SP	L	10
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	3	7-14
copper hydroxide + mancozeb	Junction	L	7-14
fenarimol	Rubigan	2	7-14
fludioxonil	Medallion	3+	7
fluoxastrobin	Disarm	3+	14-28
flutolanil	Prostar	3+	14-21
hydrogen dioxide	Zerotol	1	7
iprodione	Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro	3	14-28
mancozeb	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	3	7
metconazole	Tourney	L	14-21
myclobutanil	Eagle	2+	10-21
PCNB	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere	2	7-10
polyoxin D	Endorse	3+	7-14
propiconazole	Banner MAXX, Spectator, Savvi	2+	10-21
pyraclostrobin	Insignia	4	14-28
thiophanate-methyl	Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm	2+	10-14
thiram	Spotrete, Thiram	2	7-10
triadimefon	Bayleton, Proturf Fungicide VII	2	14-30
trifloxystrobin	Compass	4	14-21
triticonazole	Trinity, Triton	3	14-28
vinclozolin	Curalan, Touché	1	14-28
* 4 applies to two-week spray interval, 3 to four-week interval.			

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Copper Spot

Pathogen: *Gloeocercospora sorghi*

Principal Turfgrass Hosts: Creeping bentgrass

Season: July-August

Comments: Most severe during extended periods of hot, humid weather. Biweekly preventive applications of azoxystrobin, a DMI fungicide, chlorothalonil, or a reduced-rate tank-mix of a DMI plus chlorothalonil have all provided excellent control under high disease pressure in an experiment at the University of Kentucky.

Copper Spot		Efficacy[1]	Interval (days)
Fungicide	**Some Product Names**		
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	L	7-10
copper hydroxide + mancozeb	Junction	L	7-14
fenarimol	Rubigan	L	10-28
hydrogen dioxide	Zerotol	L	7
mancozeb	Protect T/O, Mancozeb, Dithane	L	7-14
myclobutanil	Eagle	L	14
thiophanate-methyl	Cleary's 3336, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm	L	7-14
triadimefon	Bayleton	L	15-30

Dollar Spot

Pathogen: *Sclerotinia homoeocarpa*

Principal Turfgrass Hosts: All turfgrasses

Season: April-October

Comments: Most severe during humid weather with moderate temperatures. Maintain adequate nitrogen fertility. Early morning mowing, irrigation at sunrise (when needed), dragging by hose, and other practices that disperse dew will reduce dollar spot pressure. A curative program against this disease may result in less chemical use than a completely preventive spray program, especially on varieties with a degree of partial resistance, such as L-93. Follow practices for reducing the risk of fungicide resistance, as strains of *Sclerotinia homoeocarpa* resistant to benzimidazole and DMI fungicides have been found in several instances in Kentucky. Resistance to benzimidazole fungicides usually results in complete loss of disease control, whereas resistance to DMI fungicides results in reduced efficacy or shorter intervals of control. The growth regulators paclobutrazol and flurprimidol slightly suppress dollar spot development, using the same biochemical mode of action as do the DMI fungicides. Therefore, avoid repeated use of DMI fungicides for dollar spot control combined with growth regulators containing paclobutrazol or flurprimidol. This may enhance the risk of DMI resistance and could also result in excessive turf growth regulation or turf chlorosis under stressful growing conditions. Where paclobutrazol is used on creeping bentgrass for growth regulation, research indicates that fungicide rates can be reduced by 20 to 25% with no loss in dollar spot control.

Avoid high rates of DMI fungicides on putting greens during summer because of the possibility of undesirable growth-regulator effects. Repeated use of azoxystrobin (and other QoI fungicides) or flutolanil has been shown to sometimes increase dollar spot pressure, occasionally substantially. Recent studies have shown a similar effect from the fungicides fludioxonil, polyoxin D, and trifloxystrobin, as well as Silwet® L-77 surfactant. Concurrent use of such products with DMI fungicides during weather favorable for dollar spot could increase the risk of resistance to DMI fungicides in *Sclerotinia homoeocarpa*. If using thiophanate-methyl, check the pH of the water used to prepare spray solutions; if the pH is high, include a buffering agent to bring the pH to 7.0 to avoid alkaline hydrolysis. Be sure

Dollar Spot		Efficacy[1]	Interval (days)
Fungicide	**Some Product Names**		
Bacillus licheniformis	EcoGuard	2	3-14
Bacillus subtilis, strain QST 713	Rhapsody	L	7-10
boscalid	Emerald	4	14-28
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	3	7-14
copper hydroxide + mancozeb	Junction	L	7-14
fenarimol	Rubigan	3	10-30
hydrogen dioxide	Zerotol	1	7
iprodione	Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro	3+	14-28
mancozeb	Fore, Protect T/O, Dithane, Mancozeb	1	7-14
metconazole	Tourney	L	14-21
myclobutanil	Eagle	4	14-28
PCNB	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere	L	21-28
propiconazole	Banner MAXX, Spectator, Savvi	4	7-28
pyraclostrobin	Insignia	2	14
thiophanate-methyl	Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm	4	10-21
thiram	Spotrete, Thiram, Defiant	1	7-10
triadimefon	Bayleton, Proturf Fungicide VII	4	14-30
Trichoderma harzianum	Bio-trek	1	7-14
triticonazole	Trinity, Triton	4	14-28
vinclozolin	Curalan, Touché, Vorlan	4	14-28

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

to use nozzle/gallonage combinations to achieve thorough and complete spray coverage; check spray coverage using water-sensitive spray paper (available online from numerous suppliers). In particular, contact fungicides may require application volumes of 2 gal/1000 sq ft for optimal results under high disease pressure. Several studies show that efficacy of DMI fungicides is greater when sprayed than when applied as granular materials. Monthly applications of ethephon (Proxy) have been shown to increase dollar spot pressure, although this effect was not seen where Proxy was applied with trinexapac ethyl (Primo Maxx). Repeated application of Insignia 20WG was associated with enhanced algal growth in one putting-green experiment).

Fairy Ring

Pathogen: Various basidiomycete fungi

Principal Turfgrass Hosts: All turfgrasses

Season: All year

Comments: Fertilize and irrigate appropriately to mask symptoms; reduce thatch. Fungicide use to suppress symptoms is not recommended except on putting greens or croquet courts. The fungicides listed below suppress growth of some of the fungi that cause fairy ring, but aerification, adequate nitrogen fertility, use of a wetting agent, and judicious irrigation may be necessary to alleviate symptoms. Before application, irrigate the turf thoroughly the day before. Apply the fungicide mixed with a wetting agent in at least 4 gal water/1000 sq ft. Studies indicate the importance of high-volume applications and inclusion of a wetting agent for both preventive as well as curative applications. Then, unless the label specifies otherwise, apply 0.10 to 0.25 inch of irrigation immediately after application. Within label limits, frequent applications at lower rates may give better control than higher rates applied infrequently. In some (but not all) tests, application of wetting agents alone such as Revolution or Cascade Plus alleviated symptoms somewhat. Revolution has been associated with increased populations of mushrooms in one test. In some research trials, applications in early spring of DMI fungicides (Bayleton 4SC or Banner Maxx) with post-application irrigation caused temporary phytotoxicity to creeping bentgrass later in summer during hot, dry conditions. Recognize that numerous fungi can produce fairy rings. Some of these fungi are not sensitive to these fungicides at normal use rates; others may be too deep in the soil to be affected by the fungicide

Fairy Ring		**Efficacy[1],***	**Interval** *(days)*
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	3	28
flutolanil	Prostar	3	30
hydrogen dioxide	Zerotol	L	7
metconazole	Tourney	L	21
pyraclostrobin	Insignia	3	28
polyoxin D	Endorse	2+	7
* Efficacy rating assumes application with a wetting agent in at least 4 gal water/1000 sq ft.			

Gray Leaf Spot

Pathogen: *Pyricularia oryzae (= Pyricularia grisea)*

Principal Turfgrass Host: Perennial ryegrass

Season: July-September

Comments: Develops during warm, humid weather in mid- to late summer and early autumn. Keep nitrogen fertility low during the summer to reduce susceptibility; apply a total of no more than 0.5 lb N/1000 sq ft during spring and summer. Fungicide protection is generally necessary under Kentucky conditions, especially during August and early September when explosive (= logarithmic) disease increase is possible. During the period of logarithmic increase, only fungicides with high efficacy are recommended. However, excessive reliance on the QoI and benzimidazole fungicides runs a substantial risk of selecting fungicide-resistant strains of *P. grisea*. Therefore, compounds with moderate efficacy can and should be used for applications on either side of this treatment window; they should also be used as mixing partners with highly efficacious compounds during the period when logarithmic increase is possible. Tank-mixes of propiconazole (Banner MAXX at 1 fl oz) or triadimefon (Bayleton 50 at 1 oz) with chlorothalonil (Daconil Ultrex at 3.2 oz, for example) can provide superior control as compared to the individual products.

Gray Leaf Spot		**Efficacy[1]**	**Interval** *(days)*
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	4	14-21
chlorothalonil	Daconil Ultrex, Manicure, Echo, Pegasus L	2+	7-10
fluoxastrobin	Disarm	L	14-28
mancozeb	Fore	2	14
mancozeb + chlorothalonil	Fore Rainshield + Daconil Ultrex	3	14
metconazole	Tourney	L	14
myclobutanil + mancozeb	MANhandle	3	14
polyoxin D	Endorse	1	7-14
propiconazole	Banner MAXX, Spectator, Savvi	2	14
propiconazole + chlorothalonil	Banner MAXX + Daconil Ultrex	3	14
pyraclostrobin	Insignia	4	14-28
thiophanate-methyl	Cleary's 3336, Fungo	4	7-14
triadimefon	Bayleton 50	2	14
triadimefon + chlorothalonil	Bayleton 50 + Daconil Ultrex	3	14
trifloxystrobin	Compass	3+	14-21

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

To minimize the risk of fungicide resistance, rotate frequently among fungicides having different modes of action. The wisest strategy is to switch after only one application of any given systemic mode of action, especially with QoI fungicides or thiophanate-methyl. Also advisable in reducing the risk of fungicide resistance is to tank-mix these fungicides with a contact fungicide when using them for gray leaf spot control.

New ryegrass seedlings in swards damaged by gray leaf spot are very susceptible and often need fungicidal protection until sustained periods of cool, dry weather. One study suggests that efficacy of azoxystrobin deteriorates when the turf is under extreme drought stress. The high labeled rate of Prograss herbicide applied in spring to perennial ryegrass has been shown to enhance gray leaf spot damage somewhat. Consider using the lower rate of Prograss as split applications in the spring. If using thiophanate-methyl, check the pH of the water used to prepare spray solutions; if the pH is high, include a buffering agent to bring the pH to below 7.0 to avoid alkaline hydrolysis. QoI-resistant strains of *P. grisea* have been detected in isolated locations in Kentucky and elsewhere. QoI fungicides remain an important tool for combating gray leaf spot; however, monitor treated areas for unexpected disease outbreaks. Under severe disease pressure, use of pre-mixes or tank-mixes of fungicides with different modes of action may help reduce the risk of fungicide resistance, especially if tank-mixes are rotated with each application.

Large Patch of Zoysia *(formerly Zoysia Patch)*

Pathogen: *Rhizoctonia solani*

Principal Turfgrass Hosts: Zoysia, bermudagrass

Season: April-June and September-October

Comments: Favored by chronic high soil moisture and close mowing. Bermudagrass is less susceptible and quicker to recover than zoysia. Improve drainage in affected fairways by filling low areas or installing tile drainage. Avoid overirrigation, especially in spring and autumn. Avoid adding nitrogen fertilizer in September or during periods in spring when the disease is visibly active (indicated by a bright orange color at the patch margin). On fairways, raise the mowing height by 0.25 inch in mid- to late September. Some observations suggest that mowing when the turf is soggy and growing slowly increases disease activity.

Studies suggest that disease development is not influenced by nitrogen rate and source or by preemergence herbicides. On sites with a history of the disease, one or two preventive fungicide applications can be helpful. Make the initial application when thatch temperatures drop below 70°F, usually in mid- to late September. Studies consistently show that at least one application in autumn is critical to successful control. A curative application in autumn (after disease has developed) may not show a benefit until mid-spring, but curative applications of effective products in autumn can provide some disease control the following season. Retreatment in springtime is sometimes necessary on zoysia, especially if sustained wet weather occurs in spring. Retreatment in springtime is of greatest value on sites where there is a substantial threat of bermudagrass encroachment into the thinned zoysia; applications are of less value on sites without such a risk (such as centers of fairways, newly established zoysia). If applying fungicide to zoysia in the spring, make the application when the first indication of active disease (a bright orange color at the patch margin) is observed. On bermudagrass, late-spring fertilization with nitrogen will help many swards outgrow the damage without the need for springtime application of fungicide. Use the highest labeled rate of the product selected, and apply in a minimum of 2.5 gal water/1000 sq ft. There is no need to irrigate or syringe after application if clippings are not being removed.

Large Patch of Zoysia *(formerly Zoysia Patch)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	4	28	
chloroneb	Terraneb SP	L	21-28	
fluoxastrobin	Disarm*	L	14-28	
flutolanil	Prostar	4	30	
iprodione	Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro	2	14-21	
metconazole	Tourney	L	14	
myclobutanil	Eagle	2+	28	
PCNB	Cleary's PCNB, Penstar, Terraclor, Turfcide	4	21-28	
polyoxin D	Endorse	1	7-14	
propiconazole	Banner MAXX, Spectator, Savvi	2+		1x
pyraclostrobin	Insignia*	2+	14-28	
triadimefon	Bayleton	4		1x
triticonazole	Trinity, Triton	3	14-28	
* Disease not listed on federal label but may be used in accordance with manufacturer-issued 2(ee) recommendation.				

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Leaf Smuts *(Stripe Smut, Flag Smut)*

Pathogen: *Ustilago striiformis* and *Urocystis agropyri*

Principal Turfgrass Hosts: Kentucky bluegrass

Season: April-November

Comments: Avoid high nitrogen. Renovate with resistant varieties of Kentucky bluegrass or with tall fescue, which is not affected. Stripe smut may be enhanced by applications of chlorothalonil or thiram. Apply fungicide in early to mid-October; water in before drying. A single, well-timed application in early to mid-October is far superior to multiple applications in the spring. Control of these diseases is very difficult with springtime applications of fungicides. See label for specific smut diseases controlled.

Leaf Smuts *(Stripe Smut, Flag Smut)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
fenarimol	Rubigan	L		1x
hydrogen dioxide	Zerotol	L	7	
myclobutanil	Eagle	L		1-2x
propiconazole	Banner MAXX, Spectator, Savvi	L		1x
thiophanate-methyl	Cleary's 3336, Fungo, T-Storm	L		2x
triadimefon	Bayleton	L		1x

Leaf Spot and Melting Out

Pathogen: *Bipolaris* and *Drechslera* spp. (= *Helminthosporium* spp.)

Principal Turfgrass Hosts: All turfgrasses

Season: April-October

Comments: Avoid high nitrogen fertility and excessive thatch. Water deeply and infrequently to avoid drought stress. Renovate with improved cultivars. Where necessary, apply fungicides preventively. For curative applications, use products rated as 4. On high-maintenance perennial ryegrass, leaf spotting leading to leaf blighting can develop anytime extended periods of wet weather with temperatures in the 50s and lower 60s occur (depending on weather, from March through early June). Applications of triadimefon may increase disease pressure. Certain fungicides or formulation of products are labeled for only one phase (i.e., leaf spot or melting out) of this disease. Where red leaf spot (caused by *Drechslera erythrospila*) is active on creeping bentgrass, azoxystrobin has been shown to be effective; flutolanil can enhance pressure from red leaf spot on creeping bentgrass.

Leaf Spot and Melting Out		**Efficacy**[1]	**Interval** *(days)*
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	3+	14-21
captan	Captan	L	7-10
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	2+	7-10
copper hydroxide + mancozeb	Junction	L	7-14
fludioxonil	Medallion	3+	14-21
fluoxastrobin	Disarm	L	14-21
hydrogen dioxide	Zerotol	L	7
iprodione	Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro	4	14-28
mancozeb	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	3+	7-14
myclobutanil	Eagle	1	14
PCNB	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere	2	21-28
polyoxin D	Endorse	L	7-14
propiconazole	Banner MAXX, Spectator, Savvi	1+	14
pyraclostrobin	Insignia	3	14-28
thiophanate-methyl	Cleary's 3336, Systec 1998, Cavalier, T-Storm	L	7-14
trifloxystrobin	Compass	2+	14-28
triticonazole	Trinity	L	14-28
vinclozolin	Curalan, Touché, Vorlan	3	14-28

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Necrotic Ring Spot

Pathogen: *Ophiosphaerella korrae*

Principal Turfgrass Hosts: Kentucky bluegrass, *Poa annua*, red fescue

Season: March-June and September-October

Comments: Control thatch buildup. Avoid high nitrogen fertility, particularly in spring and summer. Irrigate to prevent drought stress. Although deep and infrequent irrigation is recommended for management of most turf diseases, light and frequent irrigation can promote survival after an outbreak of necrotic ring spot since the disease results in a shallow root system. It may also help to apply this irrigation during the hottest part of the day. Maintain a mowing height no lower than 2 inches. Apply fungicides in April/May, and water in prior to drying on leaves. Overseed affected areas with perennial ryegrass, or renovate with resistant varieties of Kentucky bluegrass or with tall fescue. Applications of chlorothalonil may enhance disease pressure.

Necrotic Ring Spot		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	L	14-28	
fenarimol	Rubigan	3		1-2x
iprodione	Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro	2	14-21	
myclobutanil	Eagle	3	28	
propiconazole	Banner MAXX, Spectator, Savvi	2	28	
thiophanate-methyl	Cleary's 3336, Fungo, Systec 1998, T-Storm	2	10-14	

Pink Snow Mold/Microdochium Patch *(= Fusarium Patch)*

Pathogen: *Microdochium nivale* (= *Fusarium nivale*)

Principal Turfgrass Hosts: Creeping bentgrass, perennial ryegrass

Season: November-May

Comments: Common in greens and fairways seeded the previous summer or autumn. Can also be destructive in one-year-old or even older greens and in established fairways of perennial ryegrass that are overseeded annually. There are two phases of the disease: (1) the pink snow mold phase occurs under snow cover and forms discrete, circular patches; (2) the Microdochium patch phase occurs during cool, rainy weather, and the disease damage can appear much more "smeared" over the turf, often following mower or drainage patterns. Do not leave turf uncut in late autumn or winter. Remove mulches of fallen leaves. Control drifting snow. On new bentgrass seedings, provide conditions favorable for good drainage; begin spraying in early November and continue at four-week intervals until temperatures exceed 60°F during rain events (or 65°F, if the disease has recently been active). On established bentgrass that consistently experiences the disease, apply a fungicide preventively in early to mid-November and then repeat in mid- to late January. On overseeded perennial ryegrass, a single preventive application during the first half of December is optimal. Based on published reports, more consistent control can be expected by tank-mixing iprodione and chlorothalonil than by either fungicide alone. Avoid using PCNB on putting greens because of the potential for occasional phytotoxicity to creeping bentgrass and *Poa annua*, especially if temperatures unexpectedly become warm. Of the two grasses, creeping bentgrass is the more sensitive to PCNB phytotoxicity. Phytotoxicity from PCNB is most likely when temperatures exceed 70°F. Injury from PCNB has been observed on creeping bentgrass in April following applications the previous November. Recovery from a disease outbreak can be hastened by verticutting.

Pink Snow Mold/Microdochium Patch *(= Fusarium Patch)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	2+	14-28	
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo	2+	21-28	
copper hydroxide + mancozeb	Junction	L	7-14	
fenarimol	Rubigan	2		1-2x
fludioxonil	Medallion	4		1x
fluoxastrobin	Disarm	L	14-28	
hydrogen dioxide	Zerotol	L	7	
iprodione	Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro	3	variable	
iprodione + chlorothalonil	Chipco 26GT+ Daconil Ultrex, Pegasus L	3+		1-2x
mancozeb	Fore, Protect T/O, Mancozeb, Dithane	2	14-42	
metconazole	Tourney	L		1-2x
myclobutanil	Eagle	2		1-2x
PCNB	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere	3+		1x
polyoxin D	Endorse	L	7-14	
propiconazole	Banner MAXX, Spectator, Savvi	3		1x
pyraclostrobin	Insignia	3	14-28	
thiophanate-methyl	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm	3		1-2x
thiram	Spotrete, Defiant	L		2x
triadimefon	Bayleton	2	60-90	
trifloxystrobin	Compass	3		1-2x
triticonazole	Trinity, Triton	L	14-28	
vinclozolin	Curalan, Touché, Vorlan	2	10-21	

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Powdery Mildew

Pathogen: *Erysiphe graminis*

Principal Turfgrass Host: Kentucky bluegrass

Season: April-November

Comments: Confined mainly to shady areas. Avoid high N fertility. Renovate affected areas with more shade-tolerant fescues.

Powdery Mildew		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
Bacillus subtilis, strain QST 713	Rhapsody	L	7-10	
copper hydroxide + mancozeb	Junction	L	7-14	
fenarimol	Rubigan	L		1x
myclobutanil	Eagle	4	14-28	
potassium dihydrogen phosphate	Nutrol	L	7-14	
propiconazole	Banner MAXX, Spectator, Savvi	4	14-28	
triadimefon	Bayleton	4	15-30	

Pythium Blight *(= Cottony Blight)*

Pathogen: *Pythium* species, especially *P. aphanidermatum* and *P. graminicola*

Principal Turfgrass Hosts: Perennial ryegrass, creeping bentgrass, *Poa annua*

Season: June-September

Comments: Favored by hot, wet, muggy weather and is especially active when highs exceed 90°F and lows exceed 70°F for at least two to three consecutive days. Avoid excessive soil moisture and nitrogen fertility, water early in the day to allow drying before nightfall, and improve drainage and air circulation. Avoid mowing wet grass if active mycelium is present on diseased grass, which can spread spores. Short spray intervals (7 to 10 days) are sometimes needed under high disease pressure, even for the most effective products. For curative situations, research suggests that either mefanoxam or propamocarb is the preferred choice. Tank-mixes of mancozeb and chloroneb may provide poorer control than each fungicide used alone. When using fosetyl-Al, research suggests that two or more consecutive applications of this fungicide are necessary for good control under severe disease pressure; fosetyl-Al often provides poor curative control of Pythium. Phosphite (= phosphonate) materials like fosetyl-Al should be applied to plant surfaces and not syringed after application since they may undergo chemical changes in the soil that reduce effectiveness. Avoid excessive use of mefanoxam or metalaxyl since resistance to these fungicides in *Pythium aphanidermatum* has been documented on perennial ryegrass fairways on several Kentucky golf courses. An isolate of *P. aphanidermatum* resistant to QoI fungicides was found in turfgrass in Iowa, and isolates resistant to propamocarb have been found in ornamentals, suggesting a significant resistance risk to these fungicides in this turfgrass pathogen. Use seed treated with mefanoxam or metalaxyl, especially for seedings made prior to Labor Day. This seed treatment should be sufficient to protect Kentucky bluegrass, tall fescue, and fine fescues; for perennial ryegrass, a follow-up granular or spray application may be necessary if weather permits disease activity. For creeping bentgrass, the seed of which is normally not treated with fungicide, treat the soil at seeding or shortly thereafter with a systemic like mefanoxam or propamocarb; repeat at least once if the seeding was made in August. Application of flutolanil and azoxystrobin for control of brown patch have both been shown to substantially increase Pythium blight activity if conditions favor Pythium. Koban (ethazole) may cause phytotoxicity if the application is made during hot weather, especially in low gallonage; see label directions and restrictions.

Pythium Blight *(= Cottony Blight)*		**Efficacy**[1]	**Interval** *(days)*
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	2	10-14
chloroneb	Terraneb SP, Proturf Fungicide V	L	5-7
copper hydroxide + mancozeb	Junction	L	7-14
cyazofamid	Segway	3	14-21
ethazole (= etridiazole)	Koban, Terrazole	1	5-10
fluoxastrobin	Disarm	3	14
fluopicolide + propamocarb	Stellar	L	14
fosetyl-Al	Chipco Signature, Prodigy	2+	14-21
mancozeb	Fore, Protect T/O, Mancozeb, Dithane	2	5
mefenoxam	Subdue MAXX, Quell, Fenox	3	7-21
metalaxyl	Subdue 2E, Proturf Pythium Control	3	7-21
phosphite (salts of phosphorous acid)	Magellan, Biophos, Resyst, Alude, Vital	2+ to 3*	14
propamocarb	Banol	3	7-21
pyraclostrobin	Insignia	2+	10-14
* Efficacy varies somewhat among formulated products.			

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Pythium Root Dysfunction

Pathogen: *Pythium volutum, Pythium aristosporum, Pythium arrehenomanes*

Principal Turfgrass Hosts: Creeping bentgrass, *Poa annua*

Comments: This is a poorly understood disease; for several technical reasons, positive diagnosis is often very difficult. However, in Kentucky, the disease has been associated with the following circumstances: (1) established soil-based greens overlain with several inches of sand topdressing or (2) newly established, sand-based creeping bentgrass greens, especially during the first autumn. Symptoms generally occur during late spring (with symptoms progressing through the heat of summer) or during mid- to late autumn. Root infections may begin a month or more before symptoms develop.

Minimize the disease by improving drainage and aerifying as needed. A high organic-matter content in the root zone of a sand-based green can hold excessive moisture and favor infection. If this condition exists, apply one of two treatments in spring and fall: (1) aerify with 0.25-inch to 0.50-inch tines on close spacing (1.25 inches to 1.5 inches) just deeply enough to penetrate the organic layer, then fill with sand; or (2) if heavy organic matter is in the top inch, verticutting to a 1-inch depth will remove organic matter more effectively than aerification but will require longer recovery times. Increase mowing height, and reduce mowing frequency; consider using a walk-behind mower. During an active outbreak, avoid mowing when wet to reduce mechanical damage to infected grass. Overseed as soon as possible after an outbreak, but be sure to avoid use of mancozeb prior to overseeding since that material is phytotoxic to seedlings of various grasses. On sites with a history of disease, preventive fungicide applications should be applied at monthly intervals when the average soil temperature is between 55° and 68°F, especially in the springtime. Unfortunately, efficacy of fungicides against this disease has been erratic in research trials. For curative control, pyraclostrobin has been efficacious in some trials. Another useful curative approach involves two steps: (1) drench first with a contact like ethazole, (2) then follow five to seven days later with a systemic such as mefanoxam, pyraclostrobin, or fosetyl-Al.

Sprayed fungicides should be applied in at least 5 gal water/1000 sq ft or followed immediately with 0.0625 to 0.125 inch of irrigation in order to wash fungicide into the root zone. Granulars should be applied when the turf is dry or watered in after application. Koban may cause phytotoxicity if the application is made during hot weather, especially in low gallonage; see label directions and restrictions.

Pythium Root Dysfunction		Efficacy[1]	Interval (days)
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	L	10-14
cyazofamid	Segway	L	14-21
ethazole	Koban	L	5-10
fluoxastrobin	Disarm	L	14
fosetyl-Al	Aliette	L	14-21
mefanoxam	Quell	L	10-21
pyraclostrobin	Insignia*	L	14
* Disease not listed on federal label but may be used in accordance with manufacturer-issued 2(ee) recommendation.			

Red Thread

Pathogen: *Laetisaria fuciformis* (= *Corticium fuciforme*)

Principal Turfgrass Hosts: Perennial ryegrass, fine-leaf fescues, tall fescue, Kentucky bluegrass

Season: February-November

Comments: Maintain adequate nitrogen fertility. Azoxystrobin provided the best curative performance in several tests. In one test, Eagle caused foliar discoloration and stand thinning to creeping red fescue when applied for red thread control. A related disease called **Pink Patch** (*Limonomyces roseipellis*) occasionally develops during humid, mild weather in winter on creeping bentgrass and on dormant bermudagrass. Treatment against pink patch is not recommended in most circumstances. However, if considering use of a fungicide, be aware that testing indicates that flutolanil is ineffective against pink patch. Fungicides with the greatest activity against pink patch include azoxystrobin, fenarimol, iprodione, mancozeb, myclobutanil, propiconazole, and thiophanate-methyl.

Red Thread		Efficacy[1]	Interval (days)
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	4	14-28
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	3	7-10
copper hydroxide + mancozeb	Junction	L	7-14
fenarimol	Rubigan	2	30
fluoxastrobin	Disarm	L	14-28
flutolanil	Prostar	4	21-28
iprodione	Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro	3+	14
mancozeb	Fore, Protect T/O, Mancozeb, Dithane	2	7-14
metconazole	Tourney	L	14
myclobutanil	Eagle	2	14-21
polyoxin D	Endorse	4	7-14
propiconazole	Banner MAXX, Spectator, Savvi	3	14-21
pyraclostrobin	Insignia	4	14-28
thiophanate-methyl	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm	1	7-14
triadimefon	Bayleton	3	15-30
trifloxystrobin	Compass	L	14-21
triticonazole	Trinity, Triton	4	14-28
vinclozolin	Curalan, Touché, Vorlan	2	14-28

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

Rusts

Pathogen: *Puccinia graminis* and *Puccinia coronata*

Principal Turfgrass Hosts: Bluegrasses, perennial ryegrass, zoysia

Season: August-November

Comments: Maintain adequate nitrogen fertility and soil moisture to maintain turf growth. An application of nitrogen fertilizer can help a sward recover from a rust outbreak. Fungicides are commonly not necessary in actively growing turf under Kentucky conditions. See label for specific rust diseases controlled.

Rusts		Efficacy[1]	Interval (days)
Fungicide	**Some Product Names**		
azoxystrobin	Heritage	4	14-28
Bacillus subtilis, strain QST 713	Rhapsody	L	7-10
chlorothalonil	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L	3	7-14
copper hydroxide + mancozeb	Junction	L	7-14
mancozeb	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon	3	7-14
metconazole	Tourney	L	14
myclobutanil	Eagle	L	14-28
propiconazole	Banner MAXX, Spectator, Savvi	3+	14-28
pyraclostrobin	Insignia	3	14-28
thiophanate-methyl	Cleary's 3336	2+	7-14
triadimefon	Bayleton, Proturf Fungicide VII	3+	14-30
trifloxystrobin	Compass	2+	14-21
triticonazole	Trinity, Triton	L	14-28

Slime Molds

Pathogen: *Physarum* and *Fuligo* spp.

Principal Turfgrass Hosts: All turfgrasses

Season: May-October

Comments: No fungicide necessary. Fruiting structures can be removed by hosing leaves with water, mowing, poling, or brushing. Control thatch.

Spring Dead Spot

Pathogen: *Ophiosphaerella herpotricha* and *Ophiosphaerella korrae*

Principal Turfgrass Hosts: Bermudagrass

Season: April-July

Comments: For best results, use cultural control practices over several seasons since effective management of this disease requires a long-term approach which is designed to enhance the root system of bermudagrass. Avoid late-summer nitrogen fertilization; apply the final N application no later than mid-July so that the turf runs out of nitrogen by mid-September. Raise mowing height before Labor Day. Minimize thatch and soil compaction since these impede root development. Maintain good soil drainage to allow roots to flourish. Maintain adequate potassium fertility levels to enhance turf resistance to the disease. Even when soil tests indicate a high level of potassium, a long-term program of applying 80 lb K_2O/A in late autumn can improve winter-hardiness, although if soil levels are adequate, such applications will have little effect on the disease. On putting greens, avoid using topdressings with a pH above 6.0. Use ammonium sulfate or ammonium chloride fertilizers exclusively rather than nitrate-based fertilizers; wash ammonium fertilizers off leaves if applied when temperatures will exceed 80°F. If not using exclusively ammonium-based nitrogen fertilizer, maintain the soil pH around 5.2 to 5.3 (extracted in distilled water) by making light applications of flowers of sulfur (2 lb/1000 sq ft) to areas with the disease, evaluating the results for a year before re-treating. An incremental approach is recommended since overapplication of sulfur can result in slow spring greenup and temporary turf thinning, particularly in soils with a low organic matter content. Following sulfur applications, most of the acidity may be confined to the top half-inch to inch of soil, so monitor the soil pH by sampling in the top 0.5 to 1.0 inch. For turf areas where the disease has been particularly active, an aggressive midsummer aerification program has been shown to reduce disease pressure. For such areas, aerify (0.5-inch tines or less) and verticut (0.25-inch depth) in early July and again in early August as long as soil moisture is adequate for turf recovery. Football fields should not be subjected to this treatment because this will unduly compromise sod strength. Dinitroaniline (DNA) herbicides (for control of grassy annuals) may slow recovery of bermudagrass from spring dead spot damage.

Spring Dead Spot		Efficacy[1]	Interval (days)	Apps. (x)
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	2		1-2x
fenarimol	Rubigan	2		1x
fluoxastrobin	Disarm	L	14-28	
myclobutanil	Eagle	2		1-2x
propiconazole	Banner MAXX, Spectator, Savvi	1+		1-3x

Fungicidal control of this disease is very inconsistent. While disease control may be incomplete, sometimes fungicides improve survival enough to allow rapid regrowth into affected patches. Two applications—one in late August and another in late September—are optimal based on field studies although, even with these applications, control ranges from 35 to 90%. If using a single application, apply in early September. Light irrigation immediately after application will sometimes improve control, especially in spray volumes of 2 gal/1000 sq ft or less. In

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

one test, propiconazole was reported to increase susceptibility to frost and delay spring greenup. To minimize fungicide use against this disease, map areas affected by the disease and treat only those areas.

Summer Patch *(= Poa Patch)*

Pathogen: *Magnaporthe poae*

Principal Turfgrass Hosts: Kentucky bluegrass, *Poa annua*, fine fescues

Season: July-September

Comments: Raise mowing height and irrigate deeply and infrequently during mid- to late summer. Light, frequent irrigation during the heat of summer favors continued disease development, resulting in greater root rot than that which results with a deep, infrequent irrigation program. Use acidifying fertilizers as nitrogen sources, or use sulfur applications, both of which will lower soil pH; however, frequent irrigation of the turf with high pH water will counteract this effect. The most acidifying fertilizer is ammonium sulfate; sulfur-coated urea will also reduce pH but more slowly. Wash ammonium sulfate off leaves if applied when temperatures will exceed 80°F. Avoid nitrate-based fertilizers, which can enhance symptoms. Renovate with resistant varieties of Kentucky bluegrass or with perennial ryegrass. Root infections are most aggressive when the soil is warm and saturated. Therefore, aerify to reduce compaction and improve oxygenation of the soil profile. Annually, apply manganese sulfate at a rate of 2 lb/A in the spring. Preventive fungicide applications during May-August are more effective than curative treatments.

For putting greens with significant *Poa annua* infestations requiring preventive treatment against summer patch, begin preventive applications in late April to mid-May, depending on how early soils warm up. Begin preventive treatments when soil temperature at a 2-inch depth in mid-afternoon is at least 65°F for five to six consecutive days. Apply DMI fungicides at summer patch rates no later than early June to minimize the risk of excessive turf growth regulation. Avoid using topdressings with a pH above 6.0. Avoid growth regulators containing paclobutrazole or flurprimidol while high rates of DMI fungicides are in place, especially during the months of June-August, when hot weather can develop. Research has shown that putting-green turf exhibiting growth-regulating effects of DMI fungicides can suffer significantly greater infestations of algae in summer. The growth regulators mefluidide (Embark) and flurprimidol (Cutless) have been shown to enhance symptoms of summer patch. Greater effectiveness using fungicides on putting greens may be achieved by including a foliar "spoon-feeding" program of 0.25 to 0.5 lb N/1000 sq ft monthly from June through August.

For curative treatments, studies suggest that propiconazole, azoxystrobin, and myclobutanil are preferred choices. Thiophanate-methyl has provided inconsistent control as a curative treatment. and triadimefon has shown good efficacy only in a preventive use. If spraying, apply fungicides in at least 5 gal water/1000 sq ft, or wash fungicides into the root zone before they dry with 0.1 to 0.125 inch of irrigation. If applying granulars, apply when the turf is dry, then irrigate. Avoid repeated use of chlorothalonil or iprodione during mid- to late summer as these can enhance symptom development from summer patch.

Summer Patch *(= Poa Patch)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	4	14-28	
fenarimol	Rubigan	2		1-2x
fludioxonil	Medallion	L	14	
fluoxastrobin	Disarm	L	14-28	
hydrogen dioxide	Zerotol	L	7	
metconazole	Tourney	L	14	
myclobutanil	Eagle	3	28	
propiconazole	Banner MAXX, Spectator, Savvi	3+	14-28	
pyraclostrobin	Insignia	L	14-28	
thiophanate-methyl	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm	2+	10-21	
triadimefon	Bayleton	3	30	
trifloxystrobin	Compass	3	21-28	
triticonazole	Trinity, Triton	L	14-28	

Take-All Patch *(= Ophiobolus Patch)*

Pathogen: *Gaeumannomyces graminis* var. *avenae*

Principal Turfgrass Hosts: Creeping bentgrass

Season: April-October, especially April-July

Comments: Often most severe in new greens, especially when lime has been incorporated into the root zone. Avoid using topdressings with a pH above 6.0, which can enhance symptoms. Maintain adequate levels of potash and phosphate. Reduce thatch, and aerify (but curtail these activities if symptoms are present to avoid excessive stress on the grass). Maintain soil

Take-All Patch *(= Ophiobolus Patch)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	3+		2-4x
fenarimol	Rubigan	2+		2x
fluoxastrobin	Disarm	L	28	
hydrogen dioxide	Zerotol	L	7	
propiconazole	Banner MAXX, Spectator, Savvi	2+		2-4x
pyraclostrobin	Insignia	3	28	
triadimefon	Bayleton	2+		2-4x
triticonazole	Trinity, Triton	L	14-28	

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

pH between 5.5 and 6.0. Use ammonium sulfate during spring and autumn. Substitute another nitrogen source with less burn potential during summer, but minimize the use of nitrate forms of nitrogen since this can enhance the disease. Wash ammonium fertilizers off leaves if applied when temperatures will exceed 80°F to prevent foliar burn. Maintain adequate nitrogen. Remove affected patches and re-sod.

On sites with a low manganese level and a history of take-all patch, apply 2 lb soluble manganese per acre as a foliar fertilizer in the spring, avoiding summertime applications because of phytotoxicity risk. (For example, apply 5.5 lb manganese sulfate per acre to achieve 2 lb manganese per acre.) Rates as high as 6 lb manganese per acre may be needed on soils deficient in manganese.

Applications of manganese sulfate should be applied in high spray volumes sufficient to penetrate the thatch since a low spray volume could cause the material to be chemically bound in the foliage and removed with clippings. There are some high-manganese greens-grade fertilizers on the market that would supply as much as 6.5 lb of manganese per acre, and these may also be useful to control take-all. However, most of the specialty greens fertilizers on the market contain very low amounts of manganese, and it would take perhaps a dozen applications to supply the amount of manganese necessary to reduce take-all pressure.

Sprayed fungicides should be applied in at least 5 gal water/1000 sq ft or followed immediately (before they dry) with 0.125 to 0.25 inch of irrigation in order to wash fungicide into the root zone. Granular fungicides should be applied when the turf is dry and then watered in. Several studies suggest that, for outbreaks that develop during springtime, the most important time to treat preventively with fungicide is from mid-September into early November. For conditions of severe disease pressure, several applications at 21- to 28-day intervals beginning in early April are often necessary. For sites where symptoms appear or worsen during summer, studies indicate that treatments are often needed in springtime; consider a fungicide application when soil temperature at a 2-inch depth averaged over five days exceeds 55°F. Curative applications of effective fungicides in early summer have been shown to speed turf recovery. See product labels for specifics on application timing. High labeled rates have been needed for best results in several studies.

Yellow Patch *(= Low Temperature Brown Patch)*

Pathogen: *Rhizoctonia cerealis*

Principal Turfgrass Hosts: Creeping bentgrass, annual bluegrass

Season: October-April

Comments: Improve soil drainage and reduce excessive thatch. Autumn applications of nitrogen may help the turf outgrow symptoms the following spring, particularly when an application is made after the last mowing. For sites with a chronic, recurring problem, a nitrogen application in November is important in preventing late-winter turf damage. Mow as needed to avoid tall, dense growth. Of the two species, *Poa annua* is the more susceptible host. On creeping bentgrass, infections typically are confined to leaf blades only; symptoms often disappear without fungicide treatment with the onset of warm weather and regular mowing; treat only if the disease is a chronic, recurring problem. Limited field experiences suggest that azoxystrobin is the preferred fungicide for curative treatments on *Poa annua*.

Yellow Patch *(= Low Temperature Brown Patch)*		**Efficacy**[1]	**Interval** *(days)*	**Apps.** *(x)*
Fungicide	**Some Product Names**			
azoxystrobin	Heritage	L	28	
chlorothalonil	Daconil Ultrex	L	7-14	
fludioxonil	Medallion	2+		1x
fluoxastrobin	Disarm	L	28	
flutolanil	Prostar	3	21-28	
metconazole	Tourney	L		1-2x
propiconazole	Banner MAXX, Spectator, Savvi	2		1x
polyoxin D	Endorse	L	7-14	

[1] **Rating system for fungicide efficacy:** 4 = consistently good to excellent control in published experiments; 3 = good to excellent control in most experiments; 2 = fair to good control in most experiments; 1 = control is inconsistent between experiments but performs well in some instances; N = no efficacy; L = limited published data on effectiveness; + = intermediate between two efficacy categories.

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