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Chemical Control of Turfgrass Diseases 2006

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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 http://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 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 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 Q_oI (= strobilurin) fungicides and to thiophanate methyl; dollar spot to thiophanate methyl and/or DMI fungicides; gray leaf spot to Q_oI (= 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 Pythium blight resistant to Q_oI (= strobilurin) fungicides.

All systemic fungicides have some risk for development of resistance, but certain groups of fungicides are more at risk for the development of resistance 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.

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
boscalid	7	Carboximide	moderate	XMS	Emerald
captan	M4	Phthalimide	NSd	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, Pentathalon
ethazole (= etridiazole)	14	Triadiazole	NS	C	Koban, Terrazole
fenarimol	3	DMI	moderate	XMS	Rubigan AS
fludioxonil	12	Phenylpyrolle	moderate	C	Medallion
flutolanil	7	Carboximide	moderate	XMS	Prostar
fosetyl-Al	33	Phosphonate	low	PMS	Aliette, Prodigy
hydrogen dioxide	not listed	Oxidizing agent	low	SC	Zerotol
iprodione	2	Dicarboximide	moderate	LS	Chipco 26019, Chipco 26GT, Proturf Fungicide X, Iprodione Pro
mancozeb	M3	EBDC	NS	C	Fore, Manzate 200, Protect T/O, Mancozeb, Dithane, Formec, Pentathlon
mefenoxam	4	Phenylamide	high	XMS	Subdue MAXX, Quell, Mefanoxam
metalaxyl	4	Phenylamide	high	XMS	Subdue 2E, Proturf Pythium Control, Apron seed treatment
myclobutanil	3	DMI	moderate	XMS	Eagle, Golden Eagle
PCNB (= pentachloronitro-benzene, = 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
propiconazole	3	DMI	moderate	XMS	Banner MAXX, Propiconazole Pro, Spectator
pyraclostrobin	11	QoI (= strobilurin)	high	LS	Insignia
thiophanate-methyl	1	MBC	high	XMS	Cleary's 3336 Plus, Fungo, Proturf Systemic Fungicide, SysTec 1998, Cavalier, Absorb TM, T-Storm, Tee-Off
thiram	M3	DMI	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
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, a worldwide consortium of scientists representing fungicide manufacturers. 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.

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.

1. First, 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, 3rd 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 (http://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 applications rates indicated on the labels of the solo 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
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
thiophanate-methyl + flutolanil	Systar
thiophanate-methyl + mancozeb	Duosan
thiophanate-methyl + thiram	Bromosan
triadimefon + trifloxystrobin	Armada
triadimefon + thiram	Proturf Fluid Fungicide III
triadimefon + flutolanil	Prostar Plus

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 + Chipco 26GT 2SC at 4 fl oz, followed by Chipco Signature 80WG at 4 oz +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 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 provides 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 provided as well. For each disease, labeled fungicides are given an efficacy rating from one plus (+) to four pluses (++++) based on relative effectiveness. Efficacy ratings were assigned by carefully reviewing the performance of these fungicides in 672 research reports published over a 29-year period in *Fungicide and Nematicide Tests*, published annually by the American Phytopathological Society. *Fungicide and Nematicide Tests* is available on the Web at www.apsnet.org. Many dozens of 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.

Non-Target 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 non-target effects when evaluating the need for fungicide applications. It should be noted that these non-target 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.

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 the 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, EPA 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 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 treatment of 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 non-target 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 1/32 inch to 1/16 inch can make a big difference. Double-cutting (up to five times per week) or rolling (up to three times per week) are options if higher green speed is desirable, although either should be avoided if stress is an overriding concern. 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, if possible, especially on the cleanup pass.
- 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, over-watering is more detrimental than a water deficit because it prevents roots from absorbing oxygen. When irrigation is needed, apply water by hand to avoid over-irrigating, 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 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 dessication 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 afternoon to reduce heat stress, applying water to the foliage only. Do not apply 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.
- 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 (1/4-inch) tines to a depth of 1 inch or less can also help. However, be sure to blow cores off the green because 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. 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 weekly light rates that do 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.
- Use fungicides judiciously because 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.

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 over-watering, 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 Aliette 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

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
chlorothalonil	+++1/2	7-14	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo
copper hydroxide + mancozeb	++++	7-14	Junction
hydrogen dioxide	+	7	Zerotol
mancozeb	+++	7-14	Fore, Manzate 200, Protect T/O, Mancozeb, Dithane, Pentathlon
quaternary ammonium compounds	+	7-14	Algaen-X, Consan Triple Action 20, Quickstop

Anthracnose

Pathogen: *Colletotrichum graminicola*

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. During these high-risk periods, minimize practices that cause wounding (aerification and topdressing, for example); use walk-behind mowers if possible; and avoid mowing wet, "spongy" greens. If grooming practices must be used on turf

Anthracnose

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	+++	14-28	Heritage
Bacillus licheniformis	L	3-14	EcoGuard
chlorothalonil	++1/2	7-14	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
fenarimol	++	30	Rubigan
fludioxonil	++	14	Medallion†
hydrogen dioxide	L	7	Zerotol
myclobutanil	++	14-21	Eagle
polyoxin D	+++	7-14	Endorse†
propiconazole	++1/2	14-28	Banner, Spectator
pyraclostrobin	+++	14-28	Insignia
thiophanate-methyl	++	10-14	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm
triadimefon	+1/2	14-45	Bayleton, Proturf Fungicide VII
trifloxystrobin	+++1/2	14-21	Compass

†Disease not listed on federal label but may be used in accordance with manufacturer-issued 2(ee) recommendation.

[1] Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.

with a history of anthracnose, apply fungicides plus a soluble fertilizer ahead of time, and syringe to cool the turf afterward.

Basal anthracnose on *P. annua* appears to be favored by slow soil percolation. The combination of excessive soil wetness and heavy traffic can be particularly conducive to disease; therefore, improve drainage, avoid over-watering, and redirect traffic if possible. 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 grasses, 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 0.5 lb N/1000 sq ft every month, applied in split applications at intervals of 7 to 14 days), as inadequate levels of N can enhance disease severity. Raise the mowing height if possible, since studies have shown substantially increased basal rot at lower mowing heights; indeed, it may not be possible to control the disease with fungicides on *P. annua* when mowed at or below 0.125 inches.

When the disease is active, avoid abrasive practices such as topdressing, core cultivation, brushing, vertical mowing, and double-cutting. Use walk-behind mowers and reduce mowing frequency. Irrigate to avoid wilting, particularly between midday and late afternoon. Avoid the use of PGRs when anthracnose is active.

In a number of studies, preventive applications of tank-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. 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. Curative applications 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 and bensulide have been shown to enhance damage from anthracnose. 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.

Although azoxystrobin and other Q_oI fungicides have performed well in early research trials, the emergence of resistant strains appears to be a growing concern in Kentucky and nationwide. Resistance to Q_oI fungicides and to thiophanate methyl has been documented in anthracnose isolates collected from numerous locations. Avoid sequential applications of either Q_oI fungicides or of thiophanate methyl 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 Q_oI 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 + Daconil Ultrex 82.5WDG 3.2 oz; Chipco Signature 80WDG 4.0 oz + Fore Rainshield NT 80WP 8.0 oz; Banner MAXX 1,24MEC 1.0 fl oz + Daconil Ultrex 82.5WDG 3.2 oz. 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 Dead Spot

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
boscalid	L	14	Emerald
fludioxonil	L	14	Medallion
pyraclostrobin	++++	14-28	Insignia
thiophanate methyl	L	14	Cleary's 3336 Plus

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = 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.

Brown Patch (= Rhizoctonia blight)

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	++++	14-28	Heritage
Bacillus licheniformis	++	3-14	EcoGuard
captan	L	7-10	Captan
chloroneb	L	10	Terraneb SP
chlorothalonil	+++	7-14	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	++	7-14	Rubigan
fludioxonil	+++1/2	7	Medallion
flutolanil	+++1/2	14-21	Prostar
hydrogen dioxide	+	7	Zerotol
iprodione	+++	14-28	Chipco 26019, Proturf Fungicide X
mancozeb	+++	7	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon
myclobutanil	++1/2	10-21	Eagle
PCNB	++	7-10	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere
polyoxin D	+++1/2	7-14	Endorse
propiconazole	++1/2	10-21	Banner MAXX, Spectator
pyraclostrobin	++++	14-28	Insignia
thiophanate-methyl	++1/2	10-14	Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm
thiram	++	7-10	Spotrete, Thiram
triadimefon	++	14-30	Bayleton, Proturf Fungicide VII
trifloxystrobin	++++	14-21	Compass
vinclozolin	+	14-28	Curalan, Touché

When curative control is required, consider using azoxystrobin, flutolanil, 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 + Heritage 50WG + Primo MAXX led to brown patch resurgence approximately one month after applications ended. For high-maintenance tall fescue lawns, applications of Heritage 50WG at 0.2 oz or Prostar 70WP at 3 oz have provided acceptable control of brown patch for five weeks in several published tests (all rates are in 1000 sq ft). The 2.2 oz rate of Prostar 70WP has been of variable effectiveness over five-week intervals, although in several tests application rates of 1.5 to 2.2 oz have provided good control under high disease pressure when applied at four-week intervals. In tests evaluated thus far, applications of Insignia 20WG at 0.5 to 0.9 oz at four-week intervals have provided acceptable control under high disease pressure. 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.

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = 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 + chlorothalonil have all provided excellent control under high disease pressure in an experiment at the University of Kentucky.

Copper Spot

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

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. Use of either azoxystrobin or flutolanil for other diseases has been shown to often increase dollar spot pressure. 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

Dollar Spot

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
Bacillus licheniformis	++	3-14	EcoGuard
boscalid	++++/+++§	14-28	Emerald
chlorothalonil	+++	7-14	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	+++	10-30	Rubigan
hydrogen dioxide	+	7	Zerotol
iprodione	+++1/2	14-28	Chipco 26019
mancozeb	+	7-14	Fore, Protect T/O, Dithane, Mancozeb
myclobutanil	++++	14-28	Eagle
PCNB	L	21-28	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere
propiconazole	++++	7-28	Banner MAXX, Spectator
pyraclostrobin	++	14	Insignia
thiophanate-methyl	++++	10-21	Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm
thiram	+	7-10	Spotrete, Thiram, Defiant
triadimefon	++++	14-30	Bayleton, Proturf Fungicide VII
trichoderma harzianum	+	7-14	Bio-trek
vinclozolin	++++	14-28	Curalan, Touché, Vorlan

§ "++++" applies to two-week spray interval, "+++" to four-week interval.

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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. With systemic fungicides, be sure to use adequate gallonage (2 gal/1000 sq ft) to achieve thorough coverage of the crown. Several studies show that efficacy of DMI fungicides is greater when sprayed than when applied as granular materials.

Fairy Ring

Pathogen: Various basidiomycete fungi

Principal Turfgrass Hosts: All turfgrasses

Season: All year

Comments: Fertilize and irrigate appropriately to mask symptoms; reduce thatch. 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. Then, unless the label specifies otherwise, apply 0.25 inches of irrigation immediately after application. Surfactants may be needed to improve penetration of fungicide if hydrophobic thatch and soil conditions have developed. Fungicide use to suppress symptoms is not recommended except on putting greens or croquet courts. Recognize that numerous fungi can produce fairy rings. Some of these fungi are not sensitive to these fungicides at normal use rates; other may be too deep in the soil to be affected by the fungicide.

Fairy Ring

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	+++	28	Heritage
flutolanil	++1/2	30	Prostar
hydrogen dioxide	L	7	Zerotol
pyraclostrobin	L	28	Insignia
polyoxin D	L	7	Endorse†

† Disease not listed on federal label but may be used in accordance with manufacturer-issued 2(ee) recommendation.

Gray Leaf Spot

Pathogen: *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 Q_oI 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. 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 Q_oI 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

Gray Leaf Spot

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	++++	14-21	Heritage
chlorothalonil	++1/2	7-10	Daconil Ultrex, Manicure, Echo, Pegasus L
mancozeb	++	14	Fore
mancozeb + chlorothalonil	+++	14	Fore Rainshield + Daconil Ultrex
myclobutanil + mancozeb	+++	14	MANhandle
polyoxin D	+	7-14	Endorse
propiconazole	++	14	Banner MAXX, Spectator
propiconazole + chlorothalonil	+++	14	Banner MAXX + Daconil Ultrex
pyraclostrobin	++++	14-28	Insignia
thiophanate-methyl	++++	7-14	Cleary's 3336, Fungo
triadimefon	++	14	Bayleton 50
triadimefon + chlorothalonil	+++	14	Bayleton 50 + Daconil Ultrex
trifloxystrobin	+++1/2	14-21	Compass

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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. Q_oI-resistant strains of *P. grisea* have been detected in isolated locations in Kentucky and elsewhere. Q_oI 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. Improve drainage in affected fairways by filling low areas or installing tile drainage. Avoid over-irrigation, 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). Large patch is less severe at higher mowing heights, so on fairways, raise the mowing height by 0.25 inches in mid- to late September.

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. Autumn applications are the most important. However, under Kentucky conditions, re-treatment in springtime is often necessary on zoysia, especially if sustained wet weather occurs in spring. 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)

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
azoxystrobin	++++	28	Heritage
chloroneb	L	21-28	Terraneb SP
flutolanil	++++	30	Prostar
iprodione	++	14-21	Chipco 26019
myclobutanil	++1/2	28	Eagle
PCNB	++++	21-28	Cleary's PCNB, Penstar, Terraclor, Turfcide
polyoxin D	+	7-14	Endorse
propiconazole	++1/2	1X	Banner MAXX, Spectator
triadimefon	++++	1X	Bayleton

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)

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
fenarimol	L	1X	Rubigan
hydrogen dioxide	L	7	Zerotol
myclobutanil	L	1-2X	Eagle
propiconazole	L	1X	Banner MAXX, Spectator
thiophanate-methyl	L	2X	Cleary's 3336, Fungo, T-Storm
triadimefon	L	1X	Bayleton

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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 "++++". 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

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	+++1/2	14-21	Heritage
captan	L	7-10	Captan
chlorothalonil	++1/2	7-10	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
copper hydroxide + mancozeb	L	7-14	Junction
fludioxonil	L	14-41	Medallion
hydrogen dioxide	L	7	Zerotol
iprodione	++++	14-28	Chipco 26019, Proturf Fungicide X
mancozeb	+++1/2	7-14	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon
myclobutanil	+	14	Eagle
PCNB	++	21-28	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere
polyoxin D	L	7-14	Endorse
propiconazole	++	14	Banner MAXX, Spectator
pyraclostrobin	L	14-28	Insignia
thiophanate-methyl	L	7-14	Cleary's 3336, Systec 1998, Cavalier, T-Storm
trifloxystrobin	++1/2	14-28	Compass
vinclozolin	+++	14-28	Curalan, Touché, Vorlan

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

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
azoxystrobin	L	14-28	Heritage
fenarimol	+++	1-2X	Rubigan
iprodione	++	14-21	Chipco 26019
myclobutanil	+++	28	Eagle
propiconazole	++	28	Banner MAXX, Spectator
thiophanate-methyl	++	10-14	Cleary's 3336, Fungo, Systec 1998, T-Storm

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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)

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
azoxystrobin	++1/2	14-28	Heritage
chlorothalonil	++1/2	21-28	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	++	1-2X	Rubigan
fludioxonil	++++	1X	Medallion
hydrogen dioxide	L	7	Zerotol
iprodione	+++	variable	Chipco 26019, Proturf Fungicide X
iprodione + chlorothalonil	+++1/2	1-2X	Chipco 26GT + Daconil Ultrex, Pegasus L
mancozeb	++	14-42	Fore, Protect T/O, Mancozeb, Dithane
myclobutanil	++	1-2X	Eagle
PCNB	+++1/2	1X	Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere
polyoxin D	L	7-14	Endorse
propiconazole	+++	1X	Banner MAXX, Spectator
pyraclostrobin	+++	14-28	Insignia
thiophanate-methyl	+++	1-2X	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm
thiram	L	2X	Spotrete, Defiant
triadimefon	++	60-90	Bayleton
trifloxystrobin	+++	1-2X	Compass
vinclozolin	++	10-21	Curalan, Touché, Vorlan

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

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	L	once	Rubigan
myclobutanil	++++	14-28	Eagle
potassium dihydrogen phosphate	L	7-14	Nutrol
propiconazole	++++	14-28	Banner MAXX, Spectator
triadimefon	++++	15-30	Bayleton

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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 mefanoxam or propamocarb are preferred choices. 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 Q_oI 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)

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	++	10-14	Heritage
chloroneb	L	5-7	Terraneb SP, Proturf Fungicide V
copper hydroxide + mancozeb	L	7-14	Junction
ethazole (= etridiazole)	+	5-10	Koban, Terrazole
fosetyl-Al	++1/2	14-21	Chipco Aliette, Prodigy
mancozeb	++	5	Fore, Protect T/O, mancozeb, Dithane
mefenoxam	+++	7-21	Subdue MAXX, Quell
metalaxyl	+++	7-21	Subdue 2E, Proturf Pythium Control
phosphite (salts of phosphorous acid)	++½ to +++§	14	Magellan, Biophos, Resyst, Alude, Vital
propamocarb	+++	7-21	Banol
pyraclostrobin	++1/2	10-14	Insignia

§ Efficacy varies somewhat among formulated products.

Pythium Root Dysfunction

Pathogen: *Pythium* species

Principal Turfgrass Hosts: Creeping bentgrass, *Poa annua*

Comments: This is a poorly understood disease; for several technical reasons, positive diagnosis is often not achievable. However, in Kentucky the disease has been associated with the following circumstances: established soil-based greens overlain with several inches of sand topdressing; and 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. Improve drainage, and aerify as needed. 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 because that material is phytotoxic to seedlings of various grasses. On sites with a history of disease, preven-

Pythium Root Dysfunction

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	L	10-14	Heritage
ethazole	L	5-10	Koban
fosetyl-Al	L	14-21	Aliette
mefanoxam	L	10-21	Quell

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

tive fungicide applications in September-October and again in April-May may be advisable. For curative control, drench first with a contact like ethazole, then follow five to seven days later with a systemic, either a drench of mefanoxam or foliar application of fosetyl-Al. Sprayed fungicides should be applied in at least 5 gal water/1000 sq ft or followed immediately with 1/16 to 1/8 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.

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

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	++++	14-28	Heritage
chlorothalonil	+++	7-10	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	++	30	Rubigan
flutolanil	++++	21-28	Prostar
iprodione	+++1/2	14	Chipco 26019
mancozeb	++	7-14	Fore, Protect T/O, Mancozeb, Dithane
myclobutanil	++	14-21	Eagle
polyoxin D	++++	7-14	Endorse
propiconazole	+++	14-21	Banner MAXX, Spectator
pyraclostrobin	++++	14-28	Insignia
thiophanate-methyl	+	7-14	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm
triadimefon	+++	15-30	Bayleton
trifloxystrobin	L	14-21	Compass
vinclozolin	++	14-28	Curalan, Touché, Vorlan

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

Fungicide	Efficacy[1]	Typical Application Interval (Days)	Examples of Product Names
azoxystrobin	++++	14-28	Heritage
chlorothalonil	+++	7-14	Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L
copper hydroxide + mancozeb	L	7-14	Junction
mancozeb	+++	7-14	Fore, Manzate 200, Protect T/O, Dithane, Pentathlon
myclobutanil	L	14-28	Eagle
propiconazole	+++1/2	14-28	Banner MAXX, Spectator
pyraclostrobin	+++	14-28	Insignia
thiophanate-methyl	++1/2	7-14	Cleary's 3336
triadimefon	+++1/2	14-30	Bayleton, Proturf Fungicide VII
trifloxystrobin	++1/2	14-21	Compass

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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: 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, and minimize thatch. 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. Maintain the soil pH around 5.2 to 5.3 (extracted in distilled water). 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. 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 (1/2-inch tines or less) and verticut (1/4-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. 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 and water in prior to drying.

Spring Dead Spot

Fungicide	Efficacy[1]	Typical Application Interval (Days) or No. Applications (X)	Examples of Product Names
azoxystrobin	++1/2	1-2X	Heritage
copper hydroxide + mancozeb	L	7-14	Junction
fenarimol	+1/2	1X	Rubigan
myclobutanil	++1/2	1-2X	Eagle
propiconazole	+	1-3X	Banner MAXX, Spectator

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/acre in the spring. On putting greens with infestations of *Poa annua*, avoid using topdressings with a pH above 6.0.

Preventive fungicide applications during May-August are more effective than curative treatments. 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.

For curative treatments, studies at the University of Kentucky suggest that propiconazole and azoxystrobin are preferred choices. If spraying, apply fungicides in at least 5 gal water/1000 sq ft, or wash fungicides into the root zone before they dry with 1/16 to 1/8 inch of irrigation. If applying granulars, apply when the turf is dry and then irrigate.

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

For putting greens with significant *Poa annua* infestations requiring preventive treatment against summer patch, apply DMI fungicides at summer patch rates no later than early June to minimize the risk of excessive turf growth regulation. 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. Avoid repeated use of chlorothalonil or iprodione during mid- to late summer, as these can enhance symptom development from summer patch. The growth regulators mefluidide (Embark) and flurprimidol (Cutless) have also been shown to enhance symptoms of summer patch. Greater effectiveness using fungicides 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.

Summer Patch (= Poa Patch)			
Fungicide	**Efficacy[1]**	**Typical Application Interval (Days) or No. Applications (X)**	**Examples of Product Names**
azoxystrobin	++++	14-28	Heritage
fenarimol	++	1-2X	Rubigan
fludioxonil	L	14	Medallion
hydrogen dioxide	L	7	Zerotol
myclobutanil	+++	28	Eagle
propiconazole	+++1/2	14-28	Banner MAXX, Spectator
pyraclostrobin	L	14-28	Insignia
thiophanate-methyl	++1/2	10-21	Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm
triadimefon	+++	30	Bayleton
trifloxystrobin	+++	21-28	Compass

Take-All Patch *(= Ophiobolus Patch)*

Pathogen: *Gaeumannomyces graminis* var. *avenae*

Principal Turfgrass Hosts: Creeping bentgrass

Season: April-October, esp. April-July

Comments: Often most severe in new greens, especially when lime has been incorporated into the root zone. Avoid using top-dressings 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 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 manganese per acre annually in the spring or autumn, 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 because 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 Mn 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 Mn, and it would take perhaps a dozen applications to supply the amount of Mn necessary to reduce take-all pressure.

Take-All Patch (= Ophiobolus Patch)			
Fungicide	**Efficacy[1]**	**Typical Application Interval (Days) or No. Applications (X)**	**Examples of Product Names**
azoxystrobin	+++1/2	2-4X	Heritage
fenarimol	++1/2	2X	Rubigan
hydrogen dioxide	L	7	Zerotol
propiconazole	++1/2	2-4X	Banner MAXX, Spectator
pyraclostrobin	+++	28	Insignia
triadimefon	++1/2	2-4X	Bayleton

Sprayed fungicides should be applied in at least 5 gal water/1000 sq ft or followed immediately (before they dry) with 1/8 to 1/4 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 suggest that treatments in May or June may be needed. See product labels for specifics on application timing. High labeled rates have been needed for best results in several studies.

[1] *Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.*

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; only treat if the disease is a chronic, recurring problem. Limited field experience suggests that azoxystrobin is the preferred fungicide for curative treatments on *Poa annua*.

Yellow Patch (= Low Temperature Brown Patch)			
Fungicide	**Efficacy[1]**	**Typical Application Interval (Days) or No. Applications (X)**	**Examples of Product Names**
azoxystrobin	L	28	Heritage
chlorothalonil	L	7-14	Daconil Ultrex
fludioxonil	++1/2	1X	Medallion
flutolanil	+++	21-28	Prostar
propiconazole	++	1X	Banner MAXX, Spectator
polyoxin D	L	7-14	Endorse

[1] Rating system for fungicide efficacy is as follows: ++++ = consistently good to excellent control in published experiments; +++ = good to excellent control in most experiments; ++ = fair to good control in most experiments; + = control is inconsistent between experiments but performs well in some instances; – = no efficacy; L = limited published data on effectiveness; ½ = intermediate between two efficacy categories.

Listing of fungicidal products implies no endorsement by the University of Kentucky nor its representatives. Criticism of products not listed is neither implied nor intended.

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