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Chemical Control of Turfgrass Diseases 2015

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Turgrasses 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 predispose turfgrass to diseases include close mowing, inadequate or excessive nitrogen fertility, light or frequent irrigation, excessive thatch, poor drainage, and shade.

Good turf management practices often greatly reduce the impact of disease 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 completely and carefully 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 as described above. 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.
- They often must be applied repeatedly.

For these reasons, fungicide use by homeowners generally is 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 no longer are labeled for use in home lawns. PCNB (pentachloronitrobenzene or quintozene) may no longer be used on home lawns, as such use was voluntarily revoked by manufacturers.

If applying granular fungicides to home lawns, here are some guidelines to help improve results:

- If disease is not yet evident, fungicides may be applied to foliage that is either wet or dry. (In either case, wearing impermeable boots is recommended.)
- If disease is already active:
  - For control of foliar diseases, apply the fungicide when foliage is wet so that it sticks to leaf blades.
  - For control of root diseases, either apply it to dry foliage, or apply it to wet foliage followed by immediate, light irrigation to wash the product into the topmost soil layer.

Contact and Systemic Fungicides

There are two general types of fungicides. Contact fungicides, sometimes called protectant fungicides, remain on 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 only a short distance from the site of penetration; these fungicides 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, they 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 limited. These fungicides 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 vs. Curative Use

Fungicide labels usually provide a range of application rates and intervals. Fungicides can be used on a preventive basis (usually at lower rates and/or at longer 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 shorter 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.

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

Fungicide	FRAC Code[a]	Fungicide Group[b]	Risk of Resistance[c]	Mobility[d]	Some Product Names
Acibenzolar-S-methyl	P1	Benzothiadiazole	L	PMS	Daconil Action premix (see Table 2)
Azoxystrobin	11	Q_oI (= strobilurin)	H	XMS	Heritage
Bacillus licheniformis	NC	Biocontrol agent	L	C	EcoGuard
Bacillus subtilis, strain QST 713	NC	Biocontrol agent	L	C	Rhapsody
Boscalid	7	SDHI	M-H	XMS	Emerald
Captan	M4	Phthalimide	NS	C	Captan
Chloroneb	14	MA	L-NS	C	Terraneb SP, Proturf Fungicide V
Chlorothalonil	M5	Chloronitrile	NS	C	Daconil, Echo, Manicure, Chlorostar, Concorde SST, Pegasus L
Cyazofamid	21	Q_iI (Cyanoimidazole)	M-H	C	Segway
Ethazole (etridiazole)	14	Triadiazole	NS	C	Koban, Terrazole
Fenarimol	3	DMI	M	XMS	Rubigan AS
Fluazinam	29	Oxidative phosphorylation uncoupler	L-M	C	Secure
Fludioxonil	12	Phenylpyrolle	L-M	C	Medallion
Fluoxastrobin	11	Q_oI (= strobilurin)	H	XMS	Disarm
Fluopicolide	43	Benzamide	M	XMS	Stellar (a premix with propamocarb)
Flutolanil	7	SDHI	M-H	XMS	Prostar
Fosetyl-Al	33	Phosphonate	L	PMS	Chipco Signature, Prodigy
Hydrogen dioxide	NC	Oxidizing agent	L	SC	Zerotol
Iprodione	2	Dicarboximide	M-H	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, Koverall
Mefenoxam	4	Phenylamide	H	XMS	Subdue Maxx, Quell, Mefenoxam, Fenox
Metalaxyl	4	Phenylamide	H	XMS	Subdue 2E, Proturf Pythium Control, Apron seed treatment
Metconazole	3	DMI	M	XMS	Tourney
Myclobutanil	3	DMI	M	XMS	Eagle, Golden Eagle
PCNB (pentachloronitro-benzene or quintozene)	14	MA	L-NS	C	Defend, Penstar, Terraclor, Turfcide, Revere
Penthiopyrad	7	SDHI	M-H	XMS	Velista
Phosphite (salts of phosphorous acid)	33	Phosphonate	L	PMS	Appear, Magellan, Biophos, Resyst, Alude, Vital
Polyoxin D zinc salt	19	Polyoxin	M	LS	Affirm
Propamocarb	28	Carbamate	M	LS	Banol, Stellar (a premix with fluopicolide)
Propiconazole	3	DMI	M	XMS	Banner Maxx, Propiconazole Pro, Spectator, Savvi
Pyraclostrobin	11	Q_oI (= strobilurin)	H	LS	Insignia
Tebuconazole	3	DMI	M	XMS	Torque
Thiophanate-methyl	1	MBC	H	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	M	XMS	Bayleton, Proturf Fungicide VII
Trichoderma harzianum	NC	Biocontrol agent	L	C	Bio-Trek, Turfshield, TurfMate
Trifloxystrobin	11	Q_oI (= strobilurin)	H	LS	Compass
Triticonazole	3	DMI	M	XMS	Trinity, Triton
Vinclozolin	2	Dicarboximide	M-H	LS	Curalan, Touché, Vorlan

[a] NC = Not classified. 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] L = low; M = medium; H = highl NS = not significant.

[d] C = contact (= protectant) fungicide; LS = locally systemic; XMS = xylem-mobile systemic; PMS = phloem-mobile systemic; SC = surface contact (no residue remains on leaf surface).

Fungicide Resistance

Infectious fungi sometimes develop resistance to particular fungicides, especially when a product is used repeatedly without alternating with 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 resistance to Q_oI (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. Available contact fungicides essentially have 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 develop in swards where these principles are practiced.

- 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 in order to develop resistance.
- 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 (=different FRAC Codes).
- When using an at-risk fungicide, tank-mix it with a fungicide having another biochemical target site to reduce the risk of resistance buildup (but refer to fungicide labels before tank-mixing to ensure compatibility and to avoid phytotoxicity).
- Be sure to use proper nozzles and adequate carrier volume—especially when tank-mixing a contact fungicide with an at-risk fungicide—to assure thorough coverage of all plant surfaces upon contact.
- 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 (FRAC), a worldwide consortium of scientists representing fungicide manufacturers; the codes are available in the tables below and at www.frac.info/frac/index.htm. Before tank-mixing pesticides, refer to product labels to ensure compatibility and to prevent phytotoxicity.

Table 2. Prepackaged fungicide mixtures.

Active Ingredients	Some Product Names
azoxystrobin + chlorothalonil	Renown
azoxystrobin + difenoconazole	Briskway
azoxystrobin + propiconazole	Headway
boscalid + chlorothalonil	Encartis
chlorothalonil, fludioxonil + propiconazole	Instrata
chlorothalonil, iprodione, thiophanate-methyl + tebuconazole	Enclave
chlorothalonil + propiconazole	Concert
chlorothalonil + acibenzolar-S-methyl	Daconil Action
copper hydroxide + mancozeb	Junction
fluoxastrobin + chlorothalonil	Disarm C
fluopicolide + propamocarb	Stellar
iprodione + thiophanate-methyl	Proturf Fluid Fungicide
iprodione + trifloxystrobin	Interface
pyraclostrobin + boscalid	Honor
pyraclostrobin + triticonazole	Pillar
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 + iprodione	Lesco Twosome
thiophanate-methyl + mancozeb	Duosan
thiophanate-methyl + thiram	Bromosan
triadimefon + Thiram	Proturf Fluid Fungicide III
triadimefon + flutolanil	Prostar Plus
trifloxystrobin + triadimefon	Armada, Tartan
triticonazole + chlorothalonil	Reserve

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 generally provide some protection against fungicide resistance and typically provide a broader spectrum of activity against turfgrass diseases. Also, improved disease control (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—important because the application rate of an active ingredient in a prepackaged mixture might not be as high as the rate when that same active ingredient is formulated alone.

Evaluating 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 also is 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 960 research reports published over a 36-year period in *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, principally universities, also were evaluated. Experimental results were evaluated only from validly conducted experiments with products used in a manner similar to label directions. For each disease, results from numerous scientifically valid experiments were used in assigning ratings.

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 from scientifically valid evaluations.

Efficacy ratings in this publication are not a substitute for instructions and restrictions provided on product labels. Always use each pesticidal product in a manner consistent with its label.

Improving Spray Efficacy

For fungicides, use nozzles that provide excellent spray coverage. Use water-sensitive paper to evaluate the degree of spray coverage obtained with different nozzles. Air-induction nozzles produce large droplet sizes that help to control drift, but those droplets shatter upon impact with plant surfaces, providing excellent spray coverage.

For foliar diseases, contact fungicides sometimes provide better performance when dew is removed or allowed to dry before fungicide application, although this benefit has not been seen with systemic fungicides. It is thought that the high water volume sometimes present with dew causes some of the contact fungicide applied to run off onto the thatch or soil, reducing fungicide concentration on the leaf surface. For contacts, this loss of fungicide would be expected to result in reduced performance. In contrast, for root diseases, applying fungicides (contacts or systemics) while dew is present probably enhances fungicide penetration into the root zone.

Revisiting Fungicide Synergism

As mentioned previously, 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, 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 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 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 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 remind us of the important responsibility to avoid unnecessary fungicide use.

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, or bronzing or browning of turf), and reduced growth rate. Research clearly has 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. All DMI fungicides have the potential to cause injury under selected circumstances, especially when the turf is under stress. Therefore, avoid repeated application of DMI fungicides at high rates without rotation to other modes of action when turf is under heat stress, water stress, or some other acute stress.

During hot summer months, use DMI fungicides on putting greens at low rates, and rotate them with other fungicides to

reduce overall DMI use. 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 their similar chemistries can cause significant turf growth suppression and discoloration. This damage 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.

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. Dollar spot also can be enhanced by azoxystrobin or flutolanil. The precise mechanisms of disease enhancement often are 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 was metabolized or weathered away.

Pesticide Contamination of Surface Water by Runoff

Usually, the amounts of pesticides applied to turf that move off-target in runoff are 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 or 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. Turf can range from being 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.
- Aerify fairways with hollow tines rather than solid tines.
- Do not apply in wind, and use nozzles designed to reduce spray drift to nontarget areas.

Unanticipated Detrimental Effects of Pesticides

In the past, an accepted way to evaluate the safety of chemicals was to feed them to laboratory animals at high doses and monitor for negative consequences such as poisoning, birth defects, cancer, and so on. While these studies can produce important findings, it turns out they may not identify all the harmful effects of chemicals. In recent years, scientists have discovered that even low doses of certain chemicals might have adverse effects by disrupting the endocrine system—the hormonal system of the body. Such "endocrine disruptors" can evidently cause a permanent disruption in an animal's endocrine system, even long after the exposure to the chemical and even at low doses to which humans are likely to be exposed. This endocrine system disruption can happen when the exposure occurs at critical times in the body's development, including before birth. Endocrine disruptors can produce these alterations by inducing epigenetic changes (altered gene expression), thus affecting the genetic programming of the animal's cells. Certain pesticides and other synthetic chemicals have been demonstrated to be endocrine disruptors. While there are merits to the appropriate pesticide use for management of diseases, the studies of endocrine disruptors serve once again as a reminder that synthetic chemicals sometimes pose risks that we don't understand or even know about. Thus, always do the following:

- Minimize unnecessary exposure to pesticides by using them only as part of a comprehensive IPM program.
- Consider reduced-risk pesticides when they are available.
- Always use personal protective equipment when applying any pesticide, no matter how safe you may think the product is.

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 above pH 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, the 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, such as chlorothalonil, also can be subject to alkaline hydrolysis at or above pH 8.0. 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, or 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 them 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 in summertime.

- Raise mowing height if possible. An increase of as little as 0.031 inch to 0.062 inch often can help. Reducing mowing frequency and increasing rolling frequency may also be useful practices during stress periods. According to research at both Rutgers University and Cornell University, a potential loss of quality and green speed due to reduced mowing frequency can be offset by rolling with lightweight rolling (see below). 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 combs.
- Under stressful conditions, slower green speeds resulting from reduced mowing frequency can be offset with rolling greens with lightweight rollers (vibratory or sidewinder) up to three times/week. This practice can help maintain green speed while allowing the turf to increase leaf mass and therefore its rate of photosynthesis. For best results, a rolling program should be initiated by May 1 to give the turfgrass time to adapt to the treatment before the heat of summer.
- Take care to avoid root-zone saturation, which 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 just as detrimental as 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. Consider using a wetting agent when hand-watering known dry spots. If roots are shallow, irrigate only to the depth of the roots. However, if roots are still healthy at the onset of hot weather, watering deeply and infrequently (rather than lightly and frequently) will result in a healthier turf with better carbohydrate status and root health during the most stressful weather.
- 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.
- Minimize mowing when the turf is soggy, since the equipment will sink into the turf, potentially scalping it. This practice is especially important where thatch accumulation has become excessive, and in native (e.g., loamy) soils where traffic imposed during soggy conditions will greatly increase compaction.
- For improved root-zone aeration and cooling during hot weather, "vent" greens by creating small, non-disruptive holes that allow gas exchange and keep the surface from sealing. Venting can be accomplished with needle tines, waterinjection aerification, spiking, or other means. Such non-disruptive cultivation should be done at three-week intervals beginning in early summer to maintain oxygen in the root zone, thus reducing the detrimental impact of a sudden onset of hot weather. During the heat of summer, perform these operations during evening hours to reduce stress on the turf.
- 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 systems should be monitored carefully in order to avoid removing too much water and increasing localized dry spot.
- Use foliar applications of soluble nitrogen at rates of 0.125-0.25 lb N/1,000 sq ft every 10-14 days. Avoid fertilization rates exceeding 0.25 lb of quick-release N/1,000 sq ft in a single application; too much fertilization can encourage excessive growth of disease-susceptible foliage and diminish root reserves. For a darker green color, apply 2 oz/1,000 sq ft of iron sulfate or 3 oz/1,000 sq ft of iron chelate. Some nitrogen is necessary for turf growth and stress tolerance, so don't withhold fertility

when the green is under stress. However, avoid high fertility rates in summer, as this can enhance disease activity and have other negative physiological effects on cool-season turfgrasses.
- Continue topdressing but at a light rate. 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.
- Rotate hole locations frequently to minimize traffic injury.
- Where air circulation and cooling are 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. Many herbicides, especially some oil-based and ester-based formulations, can cause turfgrass injury when applied during high temperatures.
- 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 inches 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 light spiking 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 0.125-0.25 lb of actual N/1,000 sq ft.
- During stressful periods, minimize foot traffic to the extent possible. Use ropes and other barriers to control and disperse foot traffic onto greens. Change hole locations frequently, and slow down green speed so as to open up more of the green to pin placement. Reschedule events to periods more favorable to grass growth.
- Applications of the turf growth regulator trinexapac-ethyl can help prepare turfgrass for stress periods by redirecting carbohydrates to storage instead of leaf expansion. However, multiple applications at three-week intervals are generally required for increased stress tolerance. This practice will also improve the quality and vigor of annual bluegrass (*Poa annua).*

Miscellaneous Notes

Commercial pigment products may improve the aesthetic appearance of turf. However, to our knowledge, no disease control activity has been attributed to such products in field trials.

1. Algae (not a true disease)

Pathogen: Various terrestrial blue-green and green algae
Principal hosts: Creeping bentgrass, *Poa annua*
Season: May-October

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 two 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 (carrier volume); 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, which creates a potential risk of phytotoxicity if the soil pH becomes unusually low. Potassium salts of fatty acids may be phytotoxic above 80°F.

1. Algae

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo)	M5	3.5	7-14
copper hydroxide + mancozeb (Junction)	M1 + M3	4	7-14
fluazinam (Secure) tank-mixed with another fungicide from among those listed on label	29	L	14
hydrogen dioxide (Zerotol)	NC	1	7
mancozeb (Fore, Manzate 200, Protect T/O, Mancozeb, Dithane, Pentathlon)	M3	3	7-14
quaternary ammonium compounds (Algaen-X, Consan Triple Action 20, Quickstop)	NC	1	7-14
triticonazole (Trinity, Triton)	3	2	14-28

[a] NC = Not classified.

* **Rating system for fungicide efficacy is as follows:** 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.

2. Anthracnose

Pathogen: *Colletotrichum cereale (Colletotrichum graminicola)*
Pronunciation: [kahlay-**ta**trickum] [siri-**ah**-lay]
[kahlay-**ta**trickum] [gramma-**nick**-ola]
Principal hosts: *Poa annua,* creeping bentgrass
Season: June-September on creeping bentgrass, April-September in *Poa annua*

On creeping bentgrass, the disease is associated with 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. If sowing new greens, consider adapted creeping bentgrass cultivars with moderate resistance to anthracnose (see http://www.ntep.org). Avoid the most susceptible cultivars, such as Providence, Pennlinks II, Penncross, Seaside II, and Brighton.

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:

- During cool/moist periods in early spring and even through winter if conditions are mild and wet
- Following peak periods of flowering in early summer,
- During periods of high temperature and humidity
- 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 as well as by excessively dry conditions. Excessive soil wetness can be particularly conducive to disease; therefore, improve drainage and 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: 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 if heavy organic matter is in the top inch, deep verticutting will remove organic matter more effectively than aerification but will require longer recovery times, so this practice should be used only if good growing conditions prevail. Also, avoid allowing the turf to wilt, particularly from midday to late afternoon, as that may enhance susceptibility. Irrigation that achieves 80% replacement of daily evapotranspiration (ET) is ideal from the standpoint of anthracnose management, based on studies at Rutgers University. 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 of water/1,000 sq ft, as compared to lower carrier volumes. If the disease has been active, avoid use of turf growth regulators that might delay recovery.

For both *Poa annua* and creeping bentgrass, be sure to provide sufficient soluble nitrogen to maintain a moderate growth rate through the summer (foliar applications of approximately 0.20-0.25 lb soluble N/1,000 sq ft applied every 10-14 days), as low levels of nitrogen used to promote increased ball speed can enhance disease severity. Studies in Pennsylvania suggest that a foliar nitrogen content of 5% in *Poa annua* reduces susceptibility significantly. Total nitrogen fertilization should be approximately 3 lb N/1,000 sq ft/year, with more applied in the autumn than in the spring. Raise the mowing height if possible, since studies have shown substantially increased basal

2. Anthracnose

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	3	14-28
Bacillus licheniformis (EcoGuard)	NC	L	3-14
Bacillus subtilis, strain QST 713 (Rhapsody)	NC	L	7-10
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	3	7-14
fenarimol (Rubigan)	3	2	30
fluazinam (Secure)	29	L	14
fludioxonil (Medallion)	12	2.5	14
fluoxastrobin (Disarm)	11	3	14-28
fosetyl-Al (Chipco Signature)	33	NA[c]	14
hydrogen dioxide (Zerotol)	NC	L	7
iprodione (Chipco 26 GT)	2	NA[c]	Unspecified
metconazole (Tourney)	3	3	14-21
mineral oil (Civitas)	NC	3	7-21
myclobutanil (Eagle)	3	2	14-21
penthiopyrad (Velista)	7	3.5[d]	14
phosphite (salts of phosphorous acid) (Alude)	33	2 to 3[e]	14
polyoxin D (Affirm)	19	3	7-14
propiconazole (Banner, Spectator, Savvi)	3	2	14-28
pyraclostrobin (Insignia)	11	3	14-28
tebuconazole (Torque)	3	3	28
thiophanate-methyl[b] (Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm)	1	2	10-14
triadimefon (Bayleton, Proturf Fungicide VII)	3	1.5	14-45
trifloxystrobin (Compass)	11	3.5	14-21
triticonazole (Trinity, Triton)	3	3	14-28

[a] NC = Not classified.
[b] Isolates of *C. cereale* resistant to azoxystrobin (and related Q_oI fungicides) and/or thiophanate methyl are very common in numerous locations.
[c] 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.
[d] More effective when used preventively as compared to curatively.
[e] More effective for controlling anthracnose on *Poa annua* than on creeping bentgrass.

* **Rating system for fungicide efficacy is as follows:** 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.

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 *Poa annua* when mowed at or below 0.125 inch. Lightweight vibratory rolling can help maintain acceptable green speed without increasing disease pressure.

Verticutting to a depth that could cause severe wounding of crowns and stolons (0.2 inch) has been shown to substantially enhance anthracnose damage. Shallow verticutting for grooming purposes (to a depth of 0.13 inch) has given mixed results in research trials. In one research program, weekly verticutting to 0.13 inch slightly enhanced anthracnose severity, while in another research program, biweekly verticutting to the same depth had no detrimental effect. Light, frequent topdressing (i.e., 1 cubic foot of sand/1,000 sq ft every week) through the summer consistently results in an overall improvement in anthracnose control in mid-to-late summer compared to non-topdressed plots. This improvement seems related to improving surface characteristics of the green and helping to protect the growing point from mowing, allowing for closer mowing without stressing the crown Particle shape of the sand (subangular vs. round) does not seem to influence anthracnose development. Minimize mowing when the turf is soggy, since the equipment will sink into the turf, potentially scalping it. Use walk-behind mowers, and reduce mowing frequency if the green is growing slowly. Rolling greens with lightweight rollers (vibratory or sidewinder) three times/week coupled with regular topdressing can reduce anthracnose pressure. For best results, a rolling program should be initiated by May 1 to give the turfgrass time to adapt to the treatment before the heat of summer. Irrigate to avoid wilting, particularly between midday and late afternoon. Hand water whenever possible.

Typically, preventive spray programs have been much more effective than curative programs against this disease. Mixtures of active ingredients sometimes perform better than individual active ingredients. The combination of Civitas + Harmonizer with a moderately effective fungicide sometimes results in improved fungicidal efficacy. 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 of water/1,000 sq ft. For all other fungicides, a minimum spray volume of 2 gal/1,000 sq ft coupled with nozzles providing excellent one-pass coverage is recommended. Tank-mixes of fosetyl-Al + 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. 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.

Repeated applications of trinexapac ethyl (Primo) have often reduced anthracnose severity, especially when applied at seven-day intervals, possibly by creating more uniform surface less prone to scalping. Application of ethephon (Proxy) in the spring to suppress *Poa annua* seedheads sometimes has resulted in a reduction of anthracnose severity. In almost all tests of the growth regulator mefluidide (Embark) applied for seedhead suppression, no effect on anthracnose severity has been observed. However, a program of applying mefluidide or ethephon followed by regular applications of trinexapac ethyl has resulted in slightly less anthracnose damage than achieved by application of trinexapac ethyl alone, possibly because of the combination of several stress-reducing physiological effects.

Although azoxystrobin and other Q_oI 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 Q_oI fungicides (FRAC Code 11) and to thiophanate-methyl (FRAC Code 1) have been documented in anthracnose isolates collected from many locations. Because of this resistance, superintendents should not rely on these fungicide families for anthracnose control; instead, chlorothalonil, 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 Q_oI 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 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
- Medallion 50WP 0.25 oz + Daconil Ultrex 82.5WDG 3.2 oz + 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, although 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.

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* **Rating system for fungicide efficacy is as follows:** 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.

Repeated applications of DewCure® surfactant has sometimes caused mild phytotoxicity when used alone and substantial phytotoxicity when used in combination with chlorothalonil. In several experiments, the combination of Civitas + Harmonizer caused phytotoxicity ranging from mild to severe. Turfgrass that is under biotic or abiotic stress is more prone to phytotoxicity from this combination. Phytotoxicity to creeping bentgrass managed as a putting green was observed in one test with Instrata 3.6SC and with a combination of Tourney 50WG + Primo MAXX.

3. Bentgrass/Bermudagrass Dead Spot

Pathogen: *Ophiosphaerella agrostis*
Pronunciation: [ofio-sfa-**rell**a] [a-**grow**stis]
Principal hosts: Creeping bentgrass, hybrid bermudagrass
Season: May-October (creeping bentgrass), March-May (bermudagrass)

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.

4. Brown Patch (Rhizoctonia Blight)

Pathogen: *Rhizoctonia solani*
Pronunciation: [rizoc-**toe**-nia] [so-**lay**nee]
Principal hosts: Ryegrasses, tall fescue, and bentgrasses
Season: June-September

Most severe during warm, humid weather, especially when night temperatures exceed 60°F. Avoid high nitrogen fertility during periods when conditions are conducive to disease development. 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 midsummer 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 them 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, ap-

3. Bentgrass/Bermudagrass Dead Spot

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days)**
boscalid (Emerald)	7	L	14
fludioxonil (Medallion)	12	L	14
fosetyl-Al (Chipco Signature)	33	NA[a]	14
pyraclostrobin (Insignia)	11	4	14-28
thiophanate-methyl (Cleary's 3336 Plus)	1	L	14

[a] 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.

4. Brown Patch (Rhizoctonia Blight)

Fungicide (Some product names)	**FRAC Code[a]**	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	4/3[b]	14/28[b]
Bacillus licheniformis (EcoGuard)	NC	2	3-14
Bacillus subtilis, strain QST 713 (Rhapsody)	NC	1	7-10
captan (Captan)	M4	L	7-10
chloroneb (Terraneb SP)	14	L	10
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	3	7-14
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	2	7-14
fluazinam (Secure)	29	4	14
fludioxonil (Medallion)	12	3	7
fluoxastrobin (Disarm)	11	3.5	14-28
flutolanil (Prostar)	7	3	14-21
fluxapyroxad (Xzemplar)	7	L	14-21
hydrogen dioxide (Zerotol)	NC	1	7
iprodione (Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro)	2	3	14-28
mancozeb (Fore, Manzate 200, Protect T/O, Dithane, Pentathlon)	M3	3	7
metconazole (Tourney)	3	3	14-21
mineral oil (Civitas)	NC	L	7-21
myclobutanil (Eagle)	3	2.5	10-21
PCNB (Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere)	14	2	7-10
penthiopyrad (Velista)	7	4	14
polyoxin D (Affirm)	19	3	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	3	10-21
pyraclostrobin (Insignia)	11	4	14-28
tebuconazole (Torque)	3	3	28
thiophanate-methyl (Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm)	1	2.5	10-14
thiram (Spotrete, Thiram)	M3	2	7-10
triadimefon (Bayleton, Proturf Fungicide VII)	3	2	14-30
trifloxystrobin (Compass)	11	4	14-21
triticonazole (Trinity, Triton)	3	3/2[c]	14-28
vinclozolin (Curalan, Touché)	2	1.5	14-28

[a] NC = Not classified.
[b] 4 applies to two-week spray interval, 3 to four-week interval.
[c] Lower efficacy rating applies to tall fescue at spray intervals typical for lawn care.

* **Rating system for fungicide efficacy is as follows:** 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.

plications of Cutless (flurprimidol) have been shown to reduce the efficacy of several DMI fungicides against brown patch. In several tests, Daconil Ultrex has caused mild to moderate phytotoxicity on creeping bentgrass, especially 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 azoxystrobin, fluoxastrobin, flutolanil, pyraclostrobin, or trifloxystrobin have provided acceptable control of brown patch for four to five weeks in several published tests under high disease pressure. Q_oI fungicides generally have performed best over four- to five-week application intervals. Acceptable control sometimes (but not always) has been achieved using DMI (=FRAC Code 3) fungicides, such as propiconazole. Granular formulations of fungicidal materials can provide disease suppression but sometimes do not provide complete disease control. Be aware that chlorothalonil, iprodione, PCNB, and vinclozolin are no longer labeled for use on home lawns. Also note that fungicide products marketed for residential application by homeowners have performed poorly in field experiments.

Repeated applications of commercial surfactants (such as Dew Cure®) intended to reduce dew accumulation can reduce brown patch pressure. However, repeated applications of DewCure® have caused turf yellowing in certain experiments as well as increased brown patch activity. Repeated applications of DewCure® may cause substantial phytotoxicity on annual bluegrass putting turf when used in combination with chlorothalonil.

On several turf species, failures of fungicides that are normally effective against brown patch may indicate the presence of *Chrisorhiza zeae,* the cause of leaf and sheath spot, which can sometimes be active during hot conditions. Do not rely on thiophanate-methyl for brown patch control during hot (greater than 90°F), humid conditions favorable for *C. zeae.*

Certain fine fescue cultivars are reported to be injured by chlorothalonil.

5. Brown Ring Patch

Pathogen: *Waitea circinata* var. *circinata*
Pronunciation: [way-**tay**a] [sersi-**nah**ta]
Principal hosts: *Poa annua,* creeping bentgrass, roughstalk bluegrass
Season: May-September

Damage tends to be worse on drier parts of putting greens, especially under low fertility. Addition of a half-pound to 1 pound N (in any form) often helps promote recovery. However, use caution with nitrogen applications during summer, so as to avoid favoring Pythium and brown patch activity. Primo MAXX alone sometimes has increased disease slightly in research trials, though Primo in combination with nitrogen fertility prior to symptom development has resulted in substantially less disease and improved turfgrass quality relative to untreated controls. Fungicides usually perform better if some nitrogen fertility is in place. Based on results from research trials, two applications of fungicides at a high-labeled rate may give better performance than one application and/or lower rates. Mixtures of labeled fungicides (for example, azoxystrobin + propiconazole, or polyoxin D + propiconazole) have sometimes provided superior control as compared to the same fungicides used alone.

6. Copper Spot

Pathogen: *Gloeocercospora sorghi*
Pronunciation: [glio-sir-**ca**spore-a] [**sorg**-ee]
Principal hosts: Creeping bentgrass
Season: July-August

Most severe during extended periods of hot, humid weather. In limited testing, biweekly preventive applications of the following fungicides have provided good control: azoxystrobin, chlorothalonil, fluazinam, and propiconazole + chlorothalonil.

5. Brown Ring Patch

Fungicide (Some product names)	FRAC Code	Efficacy*	Interval (days)
azoxystrobin (Heritage[a])	11	3	14-28
fludioxonil (Medallion[a])	12	3	7-14
fluoxastrobin + myclobutanil (Disarm M)	11 + 3	L	14-28
metconazole (Tourney)	3	3	14
polyoxin D (Affirm, Endorse)	19	3	7-14
propiconazole (Banner[a])	3	3	14-21
tebuconazole (Torque)	3	3	28
triticonazole (Chipco Triton)	3	3	14-28

[a] Labeled based on manufacturer-issued 2(ee) recommendation.

6. Copper Spot

Fungicide (Some product names)	FRAC Code[a]	Efficacy*	Interval (days)
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	L	7-10
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	L	10-28
hydrogen dioxide (Zerotol)	NC	L	7
mancozeb (Protect T/O, Mancozeb, Dithane)	M3	L	7-14
myclobutanil (Eagle)	3	L	14
tebuconazole (Torque)	3	L	28
thiophanate-methyl (Cleary's 3336, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm)	1	L	7-14
triadimefon (Bayleton)	3	L	15-30

[a] NC = Not classified.

* **Rating system for fungicide efficacy is as follows:** 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.

7. Dollar Spot

Pathogen: *Sclerotinia homoeocarpa*
Pronunciation: [sclero-**tin**-ia] [homio-**carp**a]
Principal hosts: All turfgrasses
Season: April-October

Most severe during humid weather with moderate temperatures. Maintain adequate nitrogen fertility. In experiments in Kentucky, early morning mowing, irrigation at sunrise (when needed), dragging by hose, and other practices that disperse dew reduced dollar spot pressure. On fairway-height turf, an "early curative" program against this disease (application made when disease is first beginning to appear) can often result in less chemical use than a completely preventive spray program, especially on varieties with a degree of partial resistance, such as L-93. On putting greens, research in Michigan shows that a consistent program of lightweight rolling once or twice per day, five days per week generally reduces dollar spot pressure. The greatest benefit of rolling occurred when performed twice in the morning following mowing. However, rolling once either in the morning or afternoon sometimes was beneficial in reducing disease pressure.

Follow practices for reducing the risk of fungicide resistance, as strains of *S. 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 combination 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 20-25% with no loss in dollar spot control. The growth regulator trinexapac-ethyl does not affect dollar spot control when used prior to disease outbreaks; however, it can slow turf recovery following an outbreak of the disease. The repeated use of flurprimidol may contribute to the development of resistance to DMI's.

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 Q_oI 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 *S. 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 to use nozzle/gallonage (carrier volume) 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/1,000 sq ft for optimal results under high disease pressure. If spraying preventively on fairways, recent research suggests two applications (the second within four weeks of the first) provide considerably longer control than one spray only. If attempting curative control after disease has become severe, fungicide mixtures (premixes or tank-mixes) are preferable for better efficacy and reduced risk of fungicide resistance, 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 or Concert 4.3SC has been associated with enhanced algal growth in certain putting-green experiments. Phytotoxicity to creeping bentgrass has been observed from applications of Trinity + Daconil, Reserve, Concert, and Banner MAXX + Daconil Ultrex.

7. Dollar Spot

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
Bacillus licheniformis (EcoGuard)	NC	2	3-14
Bacillus subtilis, strain QST 713 (Rhapsody)	NC	1	7-10
boscalid (Emerald)	7	3.5	14-28
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	3	7-14
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	3	10-30
fluazinam (Secure)	29	3	14
fluoxastrobin (Disarm)	11	1.5	14-21
fluxapyroxad (Xzemplar)	7	4	14-28
hydrogen dioxide (Zerotol)	NC	1	7
iprodione (Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro)	2	3.5	14-28
mancozeb (Fore, Protect T/O, Dithane, Mancozeb)	M3	1	7-14
metconazole (Tourney)	3	4	14-21
mineral oil (Civitas[b])	NC	2	7-21
myclobutanil (Eagle)	3	4	14-28
PCNB (Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere)	14	L	21-28
penthiopyrad (Velista)	7	2+	14
propiconazole (Banner Maxx, Spectator, Savvi)	3	4	7-28
pyraclostrobin (Insignia)	11	2.5	14
tebuconazole (Torque)	3	4	28
thiophanate-methyl (Cleary's 3336, Fungo, Proturf Systemic Fungicide, Systec 1998, Cavalier, T-Storm)	1	4	10-21
thiram (Spotrete, Thiram, Defiant)	M3	1	7-10
triadimefon (Bayleton, Proturf Fungicide VII)	3	4	14-30
Trichoderma harzianum (Bio-trek)	NC	1	7-14
triticonazole (Trinity, Triton)	3	3.5	14-28
vinclozolin (Curalan, Touché, Vorlan)	2	4	14-28

[a] NC = Not classified.
[b] Efficacy is higher with shorter labeled spray intervals.

* **Rating system for fungicide efficacy is as follows:** 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.

Applications of PCNB prior to or during hot weather may cause phytotoxicity to creeping bentgrass.

Repeated applications of commercial surfactants (such as Dew Cure®) intended to reduce dew accumulation can reduce dollar spot pressure. However, Dew Cure has caused turf yellowing in certain experiments as well as increased brown patch activity.

In several experiments, improved control of dollar spot has been achieved using reduced rates of conventional fungicides when products were co-applied with Civitas/Harmonizer. In several experiments, the combination of Civitas + Harmonizer with a propiconazole/chlorothalonil tank-mix resulted in phytotoxicity. The same combination has also been associated with enhanced algal growth on a putting green.

The fungicide product Daconil Action, a premix of chlorothalonil and acibenzolar-S-methyl, often has provided efficacy performance against dollar spot similar to that provided by chlorothalonil alone. However, in a number of experiments, this product provided somewhat longer residual control or somewhat better efficacy than that provided by chlorothalonil alone.

8. Fairy Ring

Pathogen: A complex of basidiomycete fungi
Pronunciation: [ba-**sid**io-**my**-seat]
Principal hosts: All turfgrasses
Season: All year

Fertilize with nitrogen or iron and irrigate appropriately to mask symptoms; reduce thatch. Attempt to manage putting greens with fairy ring problems so that they have a steady, consistent moisture supply in the root zone rather than experiencing regular extremes of a very wet root zone alternating with a dry root zone. Fungicide use to suppress symptoms is not recommended except on putting greens or other turfs managed at or below 0.25 inch height of cut. 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. Aerification prior to fungicide application may sometimes improve efficacy by improving soil penetration. Apply the fungicide in 2-4 gal of water/1,000 sq ft (or more, if required by the label). Some studies indicate the importance of high-volume applications as well as inclusion of a wetting agent (either the day before application or tank-mixed with the fungicide) for both preventive as well as curative applications. However, research is mixed on these points, since other studies suggest that high spray volumes and wetting agents may not improve control. Wetting agents should not be tank-mixed with DMI fungicides, as these fungicides increase the potential for phytotoxicity and may reduce efficacy. Unless the label specifies otherwise, applying 0.25 inch of irrigation immediately after fungicide application (before the fungicide has a chance to dry) helps with fungicide penetration, although studies are mixed on the importance of this practice, as well. 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. In certain tests, Revolution has resulted in increased populations of mushrooms or has caused phytotoxicity. 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 may not be sensitive to these fungicides at normal use rates; others may be too deep in the soil to be affected by the fungicide. Studies in North Carolina suggest that the optimal time to make the first application in spring is when the five-day average soil temperature reaches 55-60°F. A second application 30 days later may sometimes be necessary for season-long control. Although flutolanil is often effective, in at least one research trial testing curative applications, this fungicide enhanced fairy ring pressure rather than reducing it (highlighting the difficulty in planning a control program for this disease complex).

8. Fairy Ring

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy**[b]*	**Interval (days)**
azoxystrobin (Heritage)	11	3	28
fluoxastrobin (Disarm)	11	L	21-28
flutolanil (Prostar)	7	3	30
hydrogen dioxide (Zerotol)	NC	L	7
metconazole (Tourney)	3	3	21
polyoxin D (Affirm)	19	2.5	7
pyraclostrobin (Insignia)	11	3	28
tebuconazole (Torque[c])	3	L	28
triadimefon (Bayleton FLO)	3	3	14-21

[a] NC = Not classified.
[b] Efficacy rating assumes application with a wetting agent in at least 2 gal water/1000 sq ft.
[c] Disease not listed on federal label but may be used in accordance with manufacturer-issued 2(ee) recommendation.

9. Gray Leaf Spot

Pathogen: *Pyricularia oryzae (Pyricularia grisea)*
Pronunciation: [pie-ricku-**lar**-ia] [o-**rise**-ee]
[pie-ricku-**lar**-ia] [**gri**-sea-a]
Principal host: Perennial ryegrass
Season: July-September

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/1,000 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. oryzae.* Therefore, compounds with moderate efficacy can and should be used for applications on either side of this treatment window; they should also be

* **Rating system for fungicide efficacy is as follows:** 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.

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.

Newly emerged 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 somewhat enhance gray leaf spot damage. 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. oryzae* 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 premixes 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.

10. Large Patch of Zoysiagrass (formerly Zoysiagrass Patch)

Pathogen: *Rhizoctonia solani*
Pronunciation: [rizoc-**toe**-nia] [so-**lay**nee]
Principal hosts: Zoysia, bermudagrass
Season: April-June and September-October

Favored by chronic high soil moisture and close mowing. Bermudagrass is less susceptible and quicker to recover than zoysiagrass. 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). 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. Aerify during the peak of summer, when the large patch fungus is relatively inactive, since aerifying in early summer or late summer can result in spread of the disease. Studies suggest that disease development is not influenced by nitrogen rate and source or by pre-emergence herbicides.

On sites with a history of the disease, studies consistently show that at least one application in autumn is critical to successful control in high-pressure sites. Recent observations indicate that the disease can be active as early as the first week in August, earlier than in previous decades. It is unknown why the epidemiology of this disease is changing, but fungicide-use recommendations are currently dynamic as we continue to learn about this disease. At this time, perhaps the most rational use of preventive fungicides is to carefully map affected areas of the course and to treat these in late August to early September. A second or even third treatment is often valuable. Timing

9. Gray Leaf Spot

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	4	14-21
chlorothalonil (Daconil Ultrex, Manicure, Echo, Pegasus L)	M5	2.5	7-10
fluoxastrobin (Disarm)	11	L	14-28
mancozeb (Fore)	M3	2	14
mancozeb + chlorothalonil (Fore Rainshield + Daconil Ultrex)	M3 + M5	3	14
metconazole (Tourney)	3	2	14
mineral oil (Civitas)	NC	2.5	7-21
myclobutanil + mancozeb (MANhandle)	3 + M3	3	14
polyoxin D (Affirm)	19	1	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	2	14
propiconazole + chlorothalonil (Banner Maxx + Daconil Ultrex)	3 + M5	3	14
pyraclostrobin (Insignia)	11	4	14-28
tebuconazole (Torque)	3	L	28
thiophanate-methyl (Cleary's 3336, Fungo)	1	4	7-14
triadimefon (Bayleton 50)	3	2	14
triadimefon + chlorothalonil (Bayleton 50 + Daconil Ultrex)	3 + M3	3	14
trifloxystrobin (Compass)	11	3+	14-21

[a] NC = Not classified.

10. Large Patch of Zoysia (formerly Zoysia Patch)

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	3	28
chloroneb (Terraneb SP)	14	L	21-28
fluoxastrobin (Disarm)	11	3	14-28
flutolanil (Prostar)	7	4	30
fluxapyroxad (Xzemplar)	7	L	14-28
iprodione (Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro)	2	2	14-21
metconazole (Tourney)	3	L	14
myclobutanil (Eagle)	3	2.5	28
PCNB (Cleary's PCNB, Penstar, Terraclor, Turfcide)	14	4	21-28
penthiopyrad (Velista)	7	3	14-28
polyoxin D (Affirm)	19	1.5	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	2	1x
pyraclostrobin (Insignia)	11	3	14-28
tebuconazole (Torque)	3	3.5	1-2x
triadimefon (Bayleton)	3	4	1x
triticonazole (Trinity, Triton)	3	3	14-28

* **Rating system for fungicide efficacy is as follows:** 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.

windows for additional applications include 4-6 weeks after the first application and/or in early spring. Application in all three times may be necessary under high disease pressure. If applying curatively (after disease has developed) in autumn, the application may not show a benefit until mid-spring, but curative applications of effective products in autumn certainly can provide some disease control the following season. Re-treatment in early spring is often necessary on high-maintenance zoysiagrass fairways, especially if sustained wet weather occurs in spring. Re-treatment in springtime is of greatest value on sites where there is a substantial threat of bermudagrass encroachment into the thinned zoysiagrass; applications are of less value on sites without such a risk (such as centers of fairways, newly established zoysiagrass). If applying fungicide to zoysiagrass 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 of water/1,000 sq ft. There is no need to irrigate or syringe after application if clippings are not being removed. In limited research, a premix of azoxystrobin + propiconazole was more effective than one of trifloxystrobin + triadimefon (source PDMR 8:T019).

11. Leaf Smuts (Stripe Smut, Flag Smut)

Pathogen: *Ustilago striiformis* and *Urocystis agropyri*
Pronunciation: [u-still-**ah**go] [stria-**for**mis] [euro-**sis**tis] [agro-**pie**-ree]
Principal hosts: Kentucky bluegrass
Season: April-November

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.

12. Leaf Spot and Melting Out

Pathogen: *Bipolaris* and *Drechslera* spp. *(Helminthosporium* spp.*)*
Pronunciation: [bipo-**lar**is] [**dreck**-slurra] [hel-mintho-**spore**-ium]
Principal hosts: All turfgrasses
Season: April-October

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. Limited studies have shown poor control of Bipolaris sorokiniana on creeping bentgrass with the combination of triticonazole + chlorothalonil.

In bermudagrass, phytotoxicity has been caused by sum-

11. Leaf Smuts (Stripe Smut, Flag Smut)

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
fenarimol (Rubigan)	3	L	1x
hydrogen dioxide (Zerotol)	NC	L	7
myclobutanil (Eagle)	3	L	1-2x
propiconazole (Banner Maxx, Spectator, Savvi)	3	L	1x
tebuconazole (Torque)	3	L	1x
thiophanate-methyl (Cleary's 3336, Fungo, T-Storm)	1	L	2x
triadimefon (Bayleton)	3	L	1x

[a] NC = Not classified.

12. Leaf Spots and Melting Out

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	3	14-21
captan (Captan)	M4	L	7-10
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	2.5	7-10
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fluazinam (Secure)	29	L	14
fludioxonil (Medallion)	12	3.5	14-21
fluoxastrobin (Disarm)	11	3	14-21
hydrogen dioxide (Zerotol)	NC	L	7
iprodione (Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro)	2	3	14-28
mancozeb (Fore, Manzate 200, Protect T/O, Dithane, Pentathlon)	M3	3.5	7-14
mineral oil (Civitas)	NC	L	7-21
myclobutanil (Eagle)	3	1	14
PCNB (Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere)	14	2	21-28
penthiopyrad (Velista)	7	3.5	14
polyoxin D (Affirm)	19	L	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	2	14
pyraclostrobin (Insignia)	11	3	14-28
thiophanate-methyl (Cleary's 3336, Systec 1998, Cavalier, T-Storm)	1	2	7-14
trifloxystrobin (Compass)	11	2.5	14-28
triticonazole (Trinity)	3	L	14-28
vinclozolin (Curalan, Touché, Vorlan)	2	3.5	14-28

[a] NC = Not classified.

* **Rating system for fungicide efficacy is as follows:** 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.

mertime applications of certain DMI fungicides (FRAC Code 3; specifically, products containing metconazole, propiconazole, tebuconazole, triadimefon, or triticonazole) (source=PDMR 8:T010).

13. Necrotic Ring Spot

Pathogen: *Ophiosphaerella korrae*
Pronunciation: [ofio-sfa-**rell**a] [**core**-ee]
Principal hosts: Kentucky bluegrass, *Poa annua,* red fescue
Season: March-June and September-October

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.

14. Pink Snow Mold/Microdochium Patch

(Fusarium Patch)

Pathogen: *Microdochium nivale (Fusarium nivale)*
Pronunciation: [micro-**doke**-ium] [nee-**vah**-lee] [fyu-**sar**-ium] [nee-**vah**-lee]
Principal hosts: Creeping bentgrass, perennial ryegrass
Season: November-May

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: the pink snow mold phase occurs under snow cover and forms discrete, circular patches; and 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

13. Necrotic Ring Spot

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	L	14-28
fenarimol (Rubigan)	3	3	1-2x
iprodione (Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro)	2	2	14-21
mineral oil (Civitas)	NC	L	7-21
myclobutanil (Eagle)	3	3	28
propiconazole (Banner Maxx, Spectator, Savvi)	3	2	28
tebuconazole (Torque)	3	L	1x
thiophanate-methyl (Cleary's 3336, Fungo, Systec 1998, T-Storm)	1	2	10-14

[a] NC = Not classified.

14. Pink Snow Mold/Microdochium Patch (= Fusarium Patch)

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	2.5	14-28
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo)	M5	2.5	21-28
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	2	1-2x
fluazinam (Secure)	29	L	1-2x
fludioxonil (Medallion)	12	4	1x
fluoxastrobin (Disarm)	11	L	14-28
fluxapyroxad (Xzemplar)	7	L	14-28
hydrogen dioxide (Zerotol)	NC	L	7
iprodione (Chipco 26GT, Proturf Fungicide X, Raven, Lesco 18 Plus, Iprodione Pro)	2	3	Variable
iprodione + chlorothalonil (Chipco 26GT + Daconil Ultrex, Pegasus L)	2 + M5	3.5	1-2x
mancozeb (Fore, Protect T/O, Mancozeb, Dithane)	M3	2	14-42
metconazole (Tourney)	3	L	1-2x
mineral oil (Civitas)	NC	1	7-14
myclobutanil (Eagle)	3	2	1-2x
PCNB (Cleary's PCNB, Penstar, Terraclor, Turfcide, Revere)	14	3.5	1x
penthiopyrad (Velista)	7	3.5	1x
polyoxin D (Affirm)	19	L	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	3	1x
pyraclostrobin (Insignia)	11	3	14-28
tebuconazole (Torque)	3	L	1-2x
thiophanate-methyl (Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm)	1	3	1-2x
thiram (Spotrete, Defiant)	M3	L	2x
triadimefon (Bayleton)	3	2	60-90
trifloxystrobin (Compass)	11	3	1-2x
triticonazole (Trinity, Triton)	3	L	14-28
vinclozolin (Curalan, Touché, Vorlan)	2	2	10-21

[a] NC = Not classified.

* **Rating system for fungicide efficacy is as follows:** 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.

PCNB phytotoxicity. Phytotoxicity from PCNB is most likely when temperatures exceed 70°F. PCNB applied at high rates to creeping bentgrass or *Poa annua* in late autumn or early winter can cause turf yellowing at spring greenup. Recovery from a disease outbreak can be hastened by verticutting.

15. Powdery Mildew

Pathogen: *Blumeria graminis (Erysiphe graminis)*
Pronunciation: [blue-**mare**-ia] [**gram**-innis]
[airy-**si**-fee] [**gram**-innis]
Principal host: Kentucky bluegrass
Season: April-November

Confined mainly to shady areas. Avoid high nitrogen fertility. Renovate affected areas with more shade-tolerant tall fescues.

16. Pythium Blight (Cottony Blight)

Pathogen: Pythium species, especially *P. aphanidermatum* and *P. graminicola*
Pronunciation: [**pith**ium] [a-**fan**-idder-**may**tum]
[**pith**ium] [gramma-**nick**-ola]
Principal hosts: Perennial ryegrass, creeping bentgrass, *Poa annua*
Season: June-September

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 (7-10 days) are sometimes needed under high disease pressure, even for the most effective products. For curative situations, research suggests that mefanoxam propamocarb are the most suitable. Tank-mixes of mancozeb and chloroneb may provide poorer control than each fungicide used alone. Mixtures of chlorothalonil + acibenzolar-S-methyl have sometimes performed poorly against this disease. 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 mefenoxam 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 mefenoxam 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 mefenoxam or propamocarb; repeat at least once if the seeding was made in August. Flutolanil and azoxystrobin, when applied 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 spray gallonage; see label directions and restrictions.

15. Powdery Mildew

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
Bacillus subtilis, strain QST 713 (Rhapsody)	NC	L	7-10
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	L	1x
mineral oil (Civitas)	NC	L	7-21
myclobutanil (Eagle)	3	4	14-28
penthiopyrad (Velista)	7	L	14
potassium dihydrogen phosphate (Nutrol)	NC	L	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	4	14-28
tebuconazole (Torque)	3	L	28
triadimefon (Bayleton)	3	4	15-30

[a] NC = Not classified.

16. Pythium Blight (Cottony Blight)

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	2	10-14
chloroneb (Terraneb SP, Proturf Fungicide V)	14	L	5-7
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
cyazofamid (Segway)	21	3	14-21
ethazole (= etridiazole) (Koban, Terrazole)	14	1	5-10
fluopicolide + propamocarb (Stellar)	43 + 28	3	14
fluoxastrobin (Disarm)	11	2.5	14
fosetyl-Al (Chipco Signature, Prodigy)	33	2.5	14-21
mancozeb (Fore, Protect T/O, Mancozeb, Dithane)	M3	2	5
mefenoxam (Subdue MAXX, Quell, Fenox)	4	3	7-21
metalaxyl (Subdue 2E, Proturf Pythium Control)	4	2.5	7-21
phosphite (salts of phosphorous acid) (Appear, Alude, Biophos, Magellan, Resyst, Vital)	33	2 to 2.5[a]	14
propamocarb (Banol)	28	2.5	7-21
pyraclostrobin (Insignia)	11	2.5	10-14

[a] Efficacy varies somewhat among formulated products.

* **Rating system for fungicide efficacy is as follows:** 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.

17. Pythium Root Dysfunction

Pathogen: Principally *Pythium volutum,* possibly other *Pythium* spp.
Pronunciation: [**pith**ium] [va-**loo**tum]
Principal hosts: Creeping bentgrass, *Poa annua*

This disease is often associated with stands less than eight years old, on high-sand-content greens. In Kentucky, this disease has sometimes been associated with the following circumstances: established soil-based greens overlain with several inches of sand topdressing or 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. Symptoms often develop first on mounds or sloped areas, particularly if receiving full sun. Root infections develop most aggressively at soil temperatures between 54-75°F, although symptoms develop a month or more later, during hot weather.

Maintain adequate nitrogen fertility, as this disease is most common in nitrogen-deficient turfgrass. If the soil profile shows signs of layering, aerify as needed. A soil horizon with excessive organic-matter accumulation in the root zone of a sand-based green can hold excessive moisture and favor infection. If this condition exists, aerify in spring or fall 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; during the summer, punch with solid tines and lightly topdress to maintain adequate gas exchange. If heavy organic matter is in the top inch, deep verticutting in spring or fall will remove organic matter more effectively than aerification but will require longer recovery times, so this practice should be used only when good growing conditions prevail. During periods when soil temperatures at a 2-inch depth are between 54-75°F, avoid overly frequent irrigations. However, once symptoms develop, hand-watering severely affected areas can help affected turf remain alive. Increase mowing height above 0.125 inch during summer and reduce mowing frequency. Rolling greens daily and mowing every other day may reduce the disease and improve the tolerance of the turf to infection. Consider using a walk-behind mower. Soil surfactants may improve uniformity of water penetration into the root zone, thus assisting with irrigation management. 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.

Fungicides will be more effective if used preventively rather than curatively. On sites with a history of disease, treat preventively every 21-28 days when soil temperatures at a 2-inch depth are between 54-75°F, the temperature range under which *P. volutum* is most active. Except as noted below, sprayed fungicides should be applied in at least 4-6 gal of water/1,000 sq ft or followed immediately with 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 spray gallonage; see label directions and restrictions. In addition to the individual products listed below, tank-mixes of Signature + Banol (4 + 2 oz/1,000 sq ft) or Signature + Subdue Maxx (4 + 1 oz/1,000 sq ft) also reportedly have provided good disease suppression. These tank-mixes are reportedly most effective when applied to the foliage in 2 gal of water/1,000 sq ft.

17. Pythium Root Dysfunction

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)[a]	11	2	10-14
cyazofamid (Segway)	21	3	14-21
ethazole (Koban)	14	1	5-10
fluoxastrobin (Disarm)	11	L	14
fosetyl-Al (Chipco Signature)	33	1	14-21
mefenoxam (Quell)	4	1.5	10-21
phosphite (salts of phosphorous acid) (Appear)	33	L	7-14
propamocarb (Banol)	28	1.5	7-21
pyraclostrobin (Insignia)	11	3	14

[a] Based on a manufacturer 2(ee) recommendation.

The spray program recommended by North Carolina State University researchers (who have published the most extensive research base on this disease) is as follows:

- Insignia (0.9 oz/1,000 sq ft, watered in with 0.125 inch of irrigation).
- Segway (0.9 fl oz/1,000 sq ft, watered in with 0.125 inch of irrigation).
- Signature + Banol (4 + 2 oz/1,000 sq ft) or Signature + Subdue Maxx (4 + 1 oz/1,000 sq ft) applied in 2 gal/1,000 sq ft and left on the foliage.

This program can be used preventively every 21-28 days in the fall and spring when soil temperatures are 54-75°F. This program can also be used curatively every 14-28 days. If spraying fungicides curatively, an increased mowing height and appropriate nitrogen fertilization are necessary to allow turf recovery. Since pyraclostrobin and cyazofamid are at risk for development of resistance, be sure to rotate fungicides according to the program described above.

Application of Segway 33.3SC resulted in increased brown patch damage in one creeping bentgrass putting green test.

* **Rating system for fungicide efficacy is as follows:** 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.

18. Red Thread

Pathogen: *Laetisaria fuciformis (Corticium fuciforme)*
Pronunciation: [layta-**sar**ia] [fewsi-**for**mis] [cor-**tiss**ium] [fewsi-**for**m-a]
Principal hosts: Perennial ryegrass, fine-leaf fescues, tall fescue, Kentucky bluegrass
Season: February-November

Maintain adequate nitrogen fertility. In several tests, azoxystrobin has provided good curative performance. A recent field study also showed excellent curative recovery from an application of 1 lb urea/1,000 sq ft, without application of fungicide In that same test, good curative recovery was also observed with chlorothalonil, flutolanil, iprodione, manocozeb, pyraclostrobin, and vinclozolin. In one test, a formulation of myclobutanil (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.

19. Rhizoctonia Leaf and Sheath Spot

(previously considered a variant of Brown Patch)

Pathogen: *Chrysorhiza zeae (Rhizoctonia zeae)*
Pronunciation: [crisso-**ri**za] [**zee**-ee] [rizoc-**toe**-nia] [**zee**-ee]
Principal hosts: Creeping bentgrass, *Poa trivialis*
Season: June-August

Maintain adequate fertility, especially nitrogen and potash. A weekly application of 0.25 lb N/1,000 sq ft is advisable for at-risk greens. Manage thatch appropriately. Raise the height of cut prior to and during periods of stress, and incorporate rolling if added green speed is necessary. Aggressively verticut and aerify, but only during times of year when the turf is actively growing. On several turf species, failures of fungicides that are normally effective against brown patch may indicate the presence of *Chrysorhiza zeae,* which can sometimes be active during very hot conditions (sustained period of high temperatures in the 90s). Avoid thiophanate-methyl as a stand-alone fungicide during hot weather. Syringe fungicides before they dry. Some studies also indicate that dicarboximide fungicides (iprodione and vinclozolin, FRAC group 2) have poor effectiveness and may allow disease to develop when used as stand-alone fungicides during hot weather. Preventive fungicide applications provide best results; curative applications provide very erratic results.

18. Red Thread

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	4	14-28
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	3	7-10
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fenarimol (Rubigan)	3	2	30
fluazinam (Secure)	29	L	14
fluoxastrobin (Disarm)	11	L	14-28
flutolanil (Prostar)	7	4	21-28
iprodione (Chipco 26GT, Raven, Lesco 18 Plus, Iprodione Pro)	2	3.5	14
mancozeb (Fore, Protect T/O, Mancozeb, Dithane)	M3	2	7-14
metconazole (Tourney)	3	L	14
mineral oil (Civitas)	NC	L	7-21
myclobutanil (Eagle)	3	2	14-21
penthiopyrad (Velista)	7	4	14
polyoxin D (Affirm)	19	4	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	3	14-21
pyraclostrobin (Insignia)	11	4	14-28
tebuconazole (Torque)	3	L	28
thiophanate-methyl (Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm)	1	1	7-14
triadimefon (Bayleton)	3	3	15-30
trifloxystrobin (Compass)	11	L	14-21
triticonazole (Trinity, Triton)	3	4	14-28
vinclozolin (Curalan, Touché, Vorlan)	2	2	14-28

[a] NC = Not classified.

19. Rhizoctonia Leaf and Sheath Spot

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage TL)	11	L	14-28
chlorothalonil (Daconil Ultrex, Echo, Ensign, Equus, Mainsail)	M5	L	7-14
polyoxin D (Affirm)	19	L	7-14

* **Rating system for fungicide efficacy is as follows:** 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.

20. Rusts

Pathogen: *Puccinia coronate* and *Puccinia graminis*
Pronunciation: [puck-**sin**nia] [coro-**na**ta]
[puck-**sin**nia] [**gram**-innis]
Principal hosts: Bluegrasses, perennial ryegrass, zoysiagrass
Season: August-November

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.

21. Slime Molds

Pathogen: *Physarum* and *Fuligo* spp.
Pronunciation: [fie-**sah**rum]
[few-**lee**go]
Principal hosts: All turfgrasses
Season: May-October

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

22. Spring Dead Spot

Pathogen: *Ophiosphaerella herpotricha* and *Ophiosphaerella korrae*
Pronunciation: [ofio-sfa-**rell**a] [her-**pat**rick-a]
[ofio-sfa-**rell**a] [**core**-ee]
Principal hosts: Bermudagrass
Season: April-July

For best results, use cultural control practices over several seasons, since effective management of this disease requires a long-term approach that is designed to enhance the root system of bermudagrass. Avoid late-summer nitrogen fertilization; apply the final nitrogen 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/acre 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. Recent research in North Carolina has shown that fertilization with calcium nitrate helps suppress damage from *O. korrae,* whereas damage from *O. herpotricha* is reduced by use of ammonium sulfate. (Note: The University of Kentucky Plant Diagnostic Laboratory can differentiate these species in infected roots using a DNA-based lab technique for Kentucky samples.) If using ammonium-based fertilizers, wash them 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/1,000 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 0.5-1.0 inch of soil, so monitor the soil pH by sampling at this depth. 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, core-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 (but avoid vertical mowing after September 1). Football fields should not be subjected to aggressive vertical mowing, because this will unduly compromise sod strength. Dinitroaniline (DNA)

20. Rusts[a]

Fungicide (Some product names)	**FRAC Code**[b]	**Efficacy***	**Interval (days)**
azoxystrobin (Heritage)	11	4	14-28
Bacillus subtilis, strain QST 713 (Rhapsody)	NC	L	7-10
chlorothalonil (Daconil Ultrex, Manicure, Concorde SST, Chlorostar, Echo, Pegasus L)	M5	3	7-14
copper hydroxide + mancozeb (Junction)	M1 + M3	L	7-14
fluazinam (Secure)	29	L	14
fluoxastrobin (Disarm)	11	L	14-28
mancozeb (Fore, Manzate 200, Protect T/O, Dithane, Pentathlon)	M3	3	7-14
metconazole (Tourney)	3	L	14
myclobutanil (Eagle)	3	L	14-28
penthiopyrad (Velista)			14
propiconazole (Banner Maxx, Spectator, Savvi)	3	3.5	14-28
pyraclostrobin (Insignia)	11	3	14-28
tebuconazole (Torque)	3	L	28
thiophanate-methyl (Cleary's 3336)	1	2.5	7-14
triadimefon (Bayleton, Proturf Fungicide VII)	3	3.5	14-30
trifloxystrobin (Compass)	3	2.5	14-21
triticonazole (Trinity, Triton)	2	L	14-28

[a] Check label to assure product is labeled for the particular rust disease present.
[b] NC = Not classified.

22. Spring Dead Spot

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	2	1-2x
fenarimol (Rubigan)	3	2	1x
fluoxastrobin (Disarm)	11	L	14-28
myclobutanil (Eagle)	3	2	1-2x
propiconazole (Banner Maxx, Spectator, Savvi)	3	1.5	1-3x
tebuconazole (Torque)	3	3	2x

* **Rating system for fungicide efficacy is as follows:** 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.

pre-emergent herbicides (for control of grassy annuals) may slow recovery of bermudagrass from spring dead spot damage.

Fungicidal control of this disease can be very inconsistent; golf course superintendents are encouraged to carefully evaluate whether fungicidal control is the best course of action for their situation. Research shows that applying only one spray often provides no disease control and two to four sprays are necessary to achieve significant reductions in disease severity. Therefore, it is better to either spray several times or not use fungicides. Two applications—one in late August and another in late September (target soil temperatures at a 2-inch depth of 60-80°F)—are usually the minimum needed in Kentucky to achieve some control using fungicides although, even with these applications, control ranges from 35-90%. 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/1,000 sq ft or less. The benefit of immediate irrigation may be minimal under light disease pressure, but there is little harm in implementing the practice. While disease control may be incomplete, sometimes fungicides improve survival enough to allow rapid regrowth into affected patches. In one test, propiconazole was reported to increase susceptibility to frost and delay spring greenup. In order to minimize fungicide use against this disease, map areas affected by the disease and treat only those areas. Research on fungicide applications at spring greenup indicates that these applications provide no improvement in turfgrass recovery from disease. Applications of DMI fungicides (FRAC Code 3) may delay recovery by causing phytotoxicity, as summertime applications of certain DMI fungicides (specifically, products containing metconazole, propiconazole, tebuconazole, triadimefon, or triticonazole) have been shown to cause phytotoxicity (source=PDMR 8:T010).

23. Summer Patch (Poa Patch)

Pathogen: *Magnaporthe poae*
Pronunciation: [magna-**por**thy] [**poe**-ee]
Principal hosts: Kentucky bluegrass, *Poa annua,* fine fescues
Season: July-September

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. At symptom onset, an application of 0.2 lb of nitrogen as ammonium sulfate in 20 gal of water/1,000 sq ft can help promote recovery, although the benefit is partial and temporary. 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. Once annually, apply manganese sulfate at a rate of 2 lb/acre in the spring. Preventive fungicide applications from 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 through 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 0.25-0.5 lb N/1,000 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, control may sometimes be improved by applying fungicides in at least 5 gal of water/1,000 sq ft or by washing fungicides into the root zone before they dry with 0.1-0.125 inch of irrigation. If applying granulars, apply when the turf is dry, then irrigate. Avoid repeated use of chlorothalonil

23. Summer Patch (Poa Patch)

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	4	14-28
fenarimol (Rubigan)	3	2	1-2x
fludioxonil (Medallion)	12	L	14
fluoxastrobin (Disarm)	11	L	14-28
fluxapyroxad (Xzemplar)	7	L	14-28
hydrogen dioxide (Zerotol)	NC	L	7
metconazole (Tourney)	3	L	14
myclobutanil (Eagle)	3	3	28
propiconazole (Banner Maxx, Spectator, Savvi)	3	3	14-28
pyraclostrobin (Insignia)	11	L	14-28
tebuconazole (Torque)	3	L	28
thiophanate-methyl (Cleary's 3336, Fungo, Systec 1998, Cavalier, T-Storm)	1	2.5	10-21
triadimefon (Bayleton)	3	3	30
trifloxystrobin (Compass)	11	3	21-28
triticonazole (Trinity, Triton)	3	L	14-28

[a] NC = Not classified.

* **Rating system for fungicide efficacy is as follows:** 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.

or iprodione during mid-to-late summer, as they have been associated with enhanced symptom development from summer patch in certain tests. Torque caused phytotoxicity (yellowing, thinning) on *Poa annua* in several published tests.

24. Take-All Patch (Ophiobolus Patch)

Pathogen: *Gaeumannomyces graminis* var. *avenae*
Pronunciation: [goy-**man**no-**my**seas] [**gram**-innis] [ah-**vee**-nee]
Principal hosts: Creeping bentgrass
Season: April-October, especially April-July

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 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 they 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/acre as a foliar fertilizer in the spring, avoiding summertime applications because of phytotoxicity risk. (For example, apply 5.5 lb manganese sulfate/acre to achieve 2 lb manganese/acre.) Rates as high as 6 lb manganese/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. Some high-manganese, greens-grade fertilizers on the market would supply as much as 6.5 lb of manganese/acre, and they 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 of water/1,000 sq ft or followed immediately (before they dry) with 0.125-0.25 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; target fungicide applications when average soil temperatures at a 2-inch depth are in the range of 45-60°F. 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 springtime 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.

24. Take-All Patch (Ophiobolus Patch)

Fungicide (Some product names)	**FRAC Code**[a]	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	3.5	2-4x
fenarimol (Rubigan)	3	2.5	2x
fluoxastrobin (Disarm)	11	L	28
hydrogen dioxide (Zerotol)	NC	L	7
propiconazole (Banner Maxx, Spectator, Savvi)	3	2.5	2-4x
pyraclostrobin (Insignia)	11	3	28
tebuconazole (Torque)	3	L	1-2x
triadimefon (Bayleton)	3	2.5	2-4x
trifloxystrobin + triadimefon (Tartan)	11 + 3	L	28
triticonazole (Trinity, Triton)	3	L	14-28

[a] NC = Not classified.

25. Yellow Patch (Low-temperature Brown Patch)

Pathogen: *Ceratobasidium cereale (Rhizoctonia cerealis)*
Pronunciation: [sarah-towba-**sid**ium] [siri-**ah**-lay] [rizoc-**toe**-nia] [siri-**ah**-liss]
Principal hosts: Creeping bentgrass, annual bluegrass
Season: October-April

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 latewinter 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 usually 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.*

25. Yellow Patch (Low-temperature Brown Patch)

Fungicide (Some product names)	**FRAC Code**	**Efficacy***	**Interval (days) or Applications (x)**
azoxystrobin (Heritage)	11	L	28
chlorothalonil (Daconil Ultrex)	M5	L	7-14
fludioxonil (Medallion)	12	2.5	1x
fluoxastrobin (Disarm)	11	L	28
flutolanil (Prostar)	7	3	21-28
metconazole (Tourney)	3	L	1-2x
polyoxin D (Affirm)	19	L	7-14
propiconazole (Banner Maxx, Spectator, Savvi)	3	2	1x

* **Rating system for fungicide efficacy is as follows:** 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.

26. Yellow Tuft

Pathogen: *Sclerophthora macrospora*
Pronunciation: [scler-**off**-thora] [macro-**spore**-a]
Principal hosts: Creeping bentgrass, Kentucky bluegrass
Season: April-September

Improve soil drainage and reduce excessive thatch. Application of N fertilizer may mask symptoms but doesn't reduce infection. For curative control, two to three applications may be necessary.

26. Yellow Tuft

Fungicide (Some product names)	**FRAC Code**	**Efficacy[a]***	**Interval (days)**
fosetyl Al (Chipco Signature)	33	L	21
mefenoxam (Subdue MAXX)	4	2.5	7-21
pyraclostrobin (Insignia)	3	1	14-28

[a] Efficacy ratings pertain to curative applications; efficacy of preventive applications are unavailable.

* **Rating system for fungicide efficacy is as follows:** 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.

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 and http://turfdiseaseid.ncsu.edu/
- National Turfgrass Evaluation Program: http://www.ntep.org/
- University of Kentucky Turfgrass Disease Forecasts: http://wwwagwx.ca.uky.edu/plant_disease.html
- Purdue University Turfcast: http://btny.agriculture.purdue.edu/turfcast/

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