**Fungal Diseases of Turfgrasses in California:**
their nature, factors influencing their development, and their control

**R. M. Endo and A. H. McCain**

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**PLANT DISEASES AND FUNGI**

1) **What is a plant disease?**
   A disease includes most conditions that interfere with the normal condition or function of the plant.

2) **What is a fungal disease?**
   A disease caused by a fungus. It causes disease by attacking living plant tissues. Some fungi multiply so rapidly that the infected tissues die; others produce poisons that kill the tissue; while others gradually weaken their hosts by stealing their food and interfering with normal growth.

3) **What is a fungus?**
   A fungus is a very simple, usually microscopic plant which lacks leaves, stems, roots, flowers, and the green coloring matter, chlorophyll.

4) **Where does a fungus obtain its food?**
   The absence of chlorophyll means that a fungus cannot manufacture its food, that it must obtain it ready made from dead or living plants or animals.

5) **What is a saprophytic fungus?**
   It feeds on dead plants or animals. Fortunately, they are far more numerous than parasitic fungi.

6) **What is a parasitic fungus?**
   It feeds on living plants or animals.

7) **Are some fungi parasitic on both plants and animals?**
   No, either one or the other; not both.

8) **Are there some fungi that can feed only on living plants?**
   Yes, they are called obligate parasites. Of the 10 different kinds of fungi attacking turfgrasses in California, only the fungi causing the rust diseases are obligate parasites.

9) **Are there some kinds of fungi that are both parasitic and saprophytic?**
   Yes, such fungi are called facultative sapro- phytes or facultative parasites. Of the 10 kinds of fungi attacking turfgrasses in California, 9 of the 10 are facultative parasites.

10) **Do facultative parasites cause more damage to turfgrasses than obligate pamsites?**
    No, not usually. As a group, they are rather weak parasites which cause more damage to weakened, stunted, slow growing plants than to vigorous, rapidly growing plants. This is because vigorous growing plants not only resist disease better but also make renewed growth more rapidly. Since turfgrass can be weakened by numerous factors, facultative parasites may cause severe damage to turf.

11) **What does a fungus look like?**
    In its actively growing stage, a fungus “body” consists of delicate, microscopic threads called hyphae. The spiderweb-like threads may branch and rebranch but grow only in length.

12) **What conditions favor continued growth of the fungal threads?**
    The presence of abundant moisture, favorable temperatures, and adequate nutrients. In the absence of moisture or nutrients, the threads cease growing and may dry up and die; in the absence of suitable temperatures, growth may be slowed appreciably or stopped completely.

13) **How does a fungus “move about”?**
    a. By growth of the fungal threads through the soil and over plant surfaces.
    b. By passive transportation (e.g., by mowers, by raking, water movement, insects, foot traffic, etc.) of the fungus, or materials carrying the fungus.
    c. By wind or water dispersal of spores.

14) **What are spores?**
    Asexual fungal spores are simple reproductive bodies that are comparable to seeds. Like seeds, spores may germinate in the presence of water and favorable temperatures. If spores happen to germinate on a susceptible grass plant, they may infect it by means of fungal threads.

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1 The authors are R. M. Endo, Associate Professor of Plant Pathology, University of California, Riverside, and A.H. McCain, Extension Plant Pathologist, Berkeley.
When are spores produced?
They are produced, usually under moist conditions, following an active period of growth of the fungal threads in the infected grass plant or in dead grass debris.

Are all spores spread by the wind?
No. Dry spores produced free above the soil surface are carried by the wind, but spores that are surrounded by a sticky matrix are not. They are spread by water or wind-blown rain. Also spores of the water mold fungus, *Pythium*, possess whip-like organs that propel the spores through water.

How does fungal growth start?
By production of threads from asexual spores, infected plants, infested plant debris, or from resistant fungal structures such as chlamydospores, sexual spores, or sclerotia.

What are resistant fungal structures such as chlamydospores, sexual spores, and sclerotia?
Structures that are adapted to survive periods unfavorable for the fungus because of their thickened walls and abundant food reserves. They are usually produced by certain fungi during periods unfavorable for their growth. Because of their thick walls, they are usually resistant to the action of fungicides.

How does a fungus infect a plant?
Usually by fungus threads which may enter the plant through wounds, natural plant openings, or through intact plant surfaces.

Does the fungus grow and spread through the entire plant from a single infection?
No. Usually numerous infections are required to weaken and kill a grass plant. In general, seeds are extremely susceptible to invasion by facultative parasites, seedlings very susceptible, and plants several months old much more resistant. For example, a single *Helminthosporium* infection in a seedling may spread to involve the entire shoot; in a leaf several months old, the infected area may average only a few mm. in length. Plants with very young shoots and older leaves may therefore exhibit both large and small lesions.

Are certain kinds of fungal infections more damaging than others?
Yes, particularly infection of seedlings, infection of the very crucial crown area of the plant (where the stem and roots join), and infection by facultative parasites of stunted, weakened, plants.

FACTORS INFLUENCING FUNGAL DISEASES

What factors favor fungal disease development?
The same factors that favor fungal thread development, i.e.:

1) Occurrence of favorable temperatures. - Some fungi grow best and cause diseases at cool temperatures; others at warm temperatures (see table).

2) Presence of abundant food. - The parasitic fungi must compete not only with other fungi but with other microorganisms for available food (for example, grass clippings, and food materials leaking from healthy plants).

3) Presence of free moisture. - Water is required for prolonged periods, since all stages of fungal development require it, such as thread growth, spore production, spore germination, and plant infection. Normally, many such cycles of disease development are required for severe damage.

Which factor is most important in fungal disease development?
All 3 factors are of equal importance for the fungus. But from the grower’s point of view, moisture is the most important, since it is the only factor which he can regulate to obtain some measure of disease control.

How should grass plants be watered to suppress fungal disease development?
1) Do not water daily if at all possible; water according to need.
2) Water to a depth of at least 1-2 inches.
3) The appearance of green scum (algae) on the soil surface, or the development of wet, ill-smelling soil indicate over-watering.
4) If the grass is watered in the morning, it will remain wet only for a few hours; if watered in early evening, it will remain wet for 14 or more hours.

Since dew forms on grass blades almost daily from spring to fall, is moisture reduction really so important in reducing fungal diseases?
Yes, we believe that it is, since the kind, amount, and distribution of moisture are important. A thin water film over the entire plant is much more favorable for fungus growth than a few, scattered drops of dew.

Fungi that spread only by threads require an almost continuous film of moisture, but with fungi that spread by spores, the spores may germinate and infect plants within drops of dew. However, increasing the amount of moisture, or the duration of the wet period usually increases both the incidence and severity of both kinds of fungal diseases.

This simple truth is easily demonstrated in 2 ways: 1) most fungal diseases appear first and are most severe and damaging in shaded areas, or in areas where moisture stands for long periods because of poor wind and/or soil drainage, and 2) fungal diseases of turfgrasses are severe and damaging in the humid, wet states of the North Central, northeastern and southeastern U.S., and within California, along the foggy, coastal areas.

What diseases are spread by wind-borne spores which
relationship is reversed in the case of obligate parasites. The 2 most common and damaging turfgrass diseases in California: rust caused by *Puccinia* spp., and *Helminthosporium* leaf spot and foot rot caused by *Helm intosporium* spp. The spores of either can germinate in dew and infect plants in as short a time as 10 to 12 hours. This fact undoubtedly accounts for the prime importance of these 2 diseases in California.

27) Are weak, slow-growing plants damaged more severely by fungal pathogens than vigorous, rapidly-growing plants?

Yes, since most turfgrass diseases are caused by facultative parasites.

28) Does the type of fungal parasite make a difference?

Yes, it is generally believed that facultative parasites cause the most damage on weakened plants, the least on vigorous plants (see question 10). But this relationship is reversed in the case of obligate parasites.

29) How may grass plants be weakened?

In numerous ways but most common are the following:

1) Excess mat and thatch accumulation in the crown and root area of living plants reduces movement of water, air, and nutrients into the soil, results in loss of contact of roots with soil, and provides abundant plant debris for harboring facultative fungal parasites.

2) Too frequent mowing and/or excessive removal of foliage during periods unfavorable for plant growth probably results in a reduction of food reserves, and a sharp reduction in the number and depth of the root system.

3) Inadequate fertilization is undoubtedly the most common cause of weakened turf, yet one that is easily corrected.

30) Since accumulation of excess mat and thatch is harmful, can it be reduced or removed?

Yes, with the use of vertical mowers and other special machinery. Golf course superintendents also add soil, usually similar to the original, to restore contact of the roots with soil.

31) What diseases are most common and severe when plants are lacking in nitrogen?

Dollar spot caused by *Sclerotinia homeocarpa*, red thread caused by *Corticium fuciforme*, and rust caused by species of *Puccinia*.

32) Can these 3 diseases be controlled by adequate nitrogen fertilization?

Yes, controlled in the sense that the diseases are considerably reduced in incidence and severity.

33) How does nitrogen fertilization control these three diseases?

It is not known for sure how adequate nitrogen fertilization reduces dollar spot and red thread. We suspect that control is secured through improved plant growth since these fungi apparently require a food base in the form of dying or weakened grass blades in order to cause infection of healthy, young leaves. Rust is controlled because the rapid foliage growth resulting from nitrogen fertilization becomes only partially infected, and is rapidly removed by mowing. Since the fungus is an obligate parasite, its spores die out in the mowed leaves, and the plants thereby keep ahead of the rust. This method is not effective when plant growth slows down in winter.

34) What fungal disease is frequently associated with application of high rates of nitrogen (particularly of ammonium sulfate) which results in the rapid, soft growth of grass?

Brown patch - caused by *Rhizoctonia solani* - which commonly appears in the summer as very rapidly spreading, circular areas of affected turf (spread is by threads).

35) What is the common cause of the death of turfgrass in California?

Drought usually caused by: 1) water running off of compacted soil and usually aggravated by the too rapid application of water and, 2) water run-off due to failure of water to wet and penetrate dried-out grass debris (mat and thatch) which may be as difficult to wet as dry peat moss.

**DIAGNOSIS OF FUNGAL DISEASES**

36) How are known fungal diseases diagnosed by plant pathologists?

By noting 1) the distribution pattern of diseased plants in the field, 2) the kind of disease symptoms present on individual plants and the organs affected, and 3) the kind of fungus structures present in or on the infected cells as determined with a microscope.

37) What is meant by the disease distribution pattern?

Each fungus attacks plants in a field in a characteristic manner, depending primarily upon its method of spread. This results in a typical pattern of distribution of healthy and diseased plants or its disease distribution pattern. Turf-attacking fungi spread either by radial growth of fungal threads generally originating from a central starting point or by the wind dissemination of spores. The first type of disease spread results in gradually enlarging, circular areas of affected turf scattered among healthy areas. The second type results in the general, uniform distribution of diseased plants, with nearly all plants showing localized leaf infections, usually in the form of leaf spotting.

38) Give some examples of disease symptoms on individual plants.

The dollar spot fungus causes the death of small areas of the leaf which appear as bleached bands...
of tissue; the Helminthosporium fungi cause small brown or purplish leaf spots that are surrounded by a ring of darker colored tissue, and the Pythium fungi cause a brown, dry root rot (see table for other symptoms).

39) Give some examples of fungus structures found in or on infected plants.
In early morning it is sometimes possible to see a network of fungus threads growing in droplets of dew at the tips of infected grass blades. The “red thread” fungus forms reddish, dense, horn-like masses of fungal threads at the tips of affected grass blades; the “fairy ring” fungi form mushrooms at certain times of the year; and certain other fungi form characteristic asexual spores on characteristic spore-bearing stalks.

40) Why is diagnosis of turfgrass diseases difficult?
Since most parasitic fungi are very small and indistinguishable to the naked eye, positive identification requires confirmatory studies with the microscope. In addition, numerous saprophytic fungi occur on turfgrass plants and may be mistaken for parasites by the inexperienced.

CONTROL OF FUNGAL DISEASES

41) How are fungal diseases of turfgrasses controlled?
A) CONTROL METHODS WHICH MAY BE CONSIDERED BEFORE OR AT PLANTING TIME ARE:
1) Installing adequate water drainage facilities to prevent moisture retention, thereby minimizing the development of fungal diseases.
2) Chemical treatment of soil with gaseous toxicants such as methyl bromide to rid the soil of fungal parasites, nematodes, weed seeds, etc. This expensive procedure may be justified if the area has demonstrated a previous history of severe and chronic disease development. However, clean seed must be planted in treated soil. If dirty seed is used, fungal disease development may be more severe than if the soil had not been treated. This is because the soil microorganisms which normally compete with the fungal parasites on the seed have been killed by the soil treatment, permitting unrestricted growth of the fungal parasites on the seed.
3) Plant only fresh, clean (disease-free) seed of high viability at recommended rates of planting. Seeds and seedlings are extremely susceptible to disease and stunted, weak seedlings which result from overseeding remain very susceptible for many additional months after planting. Grass seeds grown in the far west are generally more disease-free than seed grown elsewhere in the U.S.
4) Cool season versus warm season grasses. Consider carefully whether you want to plant a cool season or a warm season grass. Cool season grasses are very susceptible to fungal parasites; warm season grasses are very resistant (e.g., bermuda grass, zoysia grass and St. Augustine grass). The cool season grasses are arranged in order of increasing disease resistance: Fescues, ryegrasses, bentgrasses, and bluegrasses.
5) If available and necessary, disease-resistant varieties of proven adaptability should be planted. This is the easiest way to control fungal diseases but very few resistant varieties of cool season grasses are available, and these are usually resistant to only a single disease.

B) CONTROL METHODS WHICH ARE APPLICABLE TO GROWING PLANTS ARE:
1) The application of protectant fungicides.
2) The use of certain cultural practices. These practices favor vigorous plant growth and are unfavorable for fungal disease development. Examples are given in question 29. These methods probably are more successful in California than elsewhere because of our very low relative humidity and low rainfall - which falls only in winter and early spring. In California these cultural methods may fail wherever low moisture distribution patterns are disturbed by the occurrence of frequent coastal fogs, by rainfall, by local topography, by the need for daily irrigations, by poor drainage situations, etc.

42) What is a protectant fungicide?
One which is applied to the external surfaces of plants to protect them from infection by fungal parasites. They are mainly effective in stopping further disease spread, not in curing infected plants of disease.

43) Is a fungicide more effective against a fungal disease spread primarily by spores or by fungal threads?
It is far more effective against fungal threads than spores. Threads are more exposed, and more readily damaged although they are far fewer numerically and less generally distributed. Poisoning of spores is more difficult primarily because of their very small size and their random distribution by wind over the host surfaces.

44) Why aren’t fungicides curative rather than protective?
Because protectant fungicides are not taken up by the plant to kill the parasite inside.

45) How long does this external protection last?
Usually from 3 to 14 days depending upon the fungicide, the weather, etc. In addition, any new growth which occurs after fungicide application will be unprotected.

46) Is the lack of cumulative action the main reason why fungicides are sometimes applied every 7 to 14 days in a so-called preventative disease control program?
Yes, that plus the fact that the effectiveness of protectant fungicides is so short-lived and new growth is unprotected.

47) When is a preventative fungicide disease control schedule recommended?
Because of the expense, labor and time involved, it is not recommended for homeowners. It is recommended for turf areas receiving intensive care and play that must

(continued)
be maintained in as healthy a condition as possible (e.g.,
golf greens and bowling greens that are mowed from 3 to 6
times weekly and that receive daily play).

48) When should a preventative fungicide disease
control program be started?
Sometime in early spring but the actual time will
vary depending upon the area, the grass variety, weather
conditions, diseases generally present, etc. In any case,
applications must be started before disease development
has progressed too far since fungicides are least effec-
tive when fungal populations are high, and most effective
when fungal populations are low.

49) What method of disease control is recommended for
the homeowner for established lawns?
Keep the grass growing in as vigorous a condi-
tion as possible as outlined in questions 22 to 35, and
use fungicides whenever necessary to stop disease spread
should diseases develop.

50) Why are different fungicides recommended for the
control of different fungal pathogens?
Because fungicides are not equally effective
against different parasitic fungi.

51) Since the exact identification of a fungal parasite
requires microscopic examination, how can one be
sure of what fungicide to use?
In most cases diagnosis is not difficult and a
proper choice of fungicide can be made. If diagnosis is
uncertain, use a mercurial-containing fungicide which
possesses the widest spectrum of activity against fungal
parasites, or use a fungicidal mixture.

52) What is a fungicidal mixture?
It consists of 2 or more fungicides mixed to-
gether to increase the number of fungal parasites that can
be controlled, to increase fungicidal efficiency, or to
increase the safety of fungicides to plants.

53) Are other chemical compounds sometimes added to
fungicidal mixtures?
Yes. Commonly added chemicals are fertilizers,
compounds containing iron, and insecticides.

54) Are fungicides harmful to plants?
Yes, if they are used at higher than recommended
rates.

55) Are some fungicides more damaging to plants at high
temperatures?
Yes, mercurials, in particular, should not be
applied when air temperatures are higher than 82°F, or
when temperatures shortly after application are expected
to rise above this temperature. Reduce the amount of
mercury used by 1/4 to 1/2 or apply in late afternoon
during hot weather.

56) Why do you recommend that certain fungicide mix-
tures or certain fungicides be used alternately in a
preventative fungicide disease control schedule?
The alternate use of different fungicides or
fungicide mixtures is recommended because development
of fungi resistant to fungicides is less likely to occur
and better protection is afforded against all the various
fungi attacking turf.

57) What 2 groups of fungicides or fungicide mixtures
are currently recommended?
Select one fungicide or fungicide mixture from
each of the 2 groups. Apply one fungicide or fungicide
mixture one week and the second fungicide or fungicide
mixture 7 to 14 days later.

Group 1 (effective against dollar spot, brown
patch, red thread, Fusarium patch and Helminthosporium-
induced diseases). 1) Phenyl mercury acetate with tetra-
methylthiuram disulfide; 2) hydroxymercuri chlorophenol
with tetramethylthiuram disulfide; 3) methyl mercuri
dicyandiamide; 4) or folpet with cadmium carbonate and
tetramethylthiuram disulfide.

Group 2 (effective against greasy spot caused by
species of Pythium and rust caused by species of Puc-
cinia). Zinc ethylene bisthiocarbamate, cyclohexamide,
or cyclohexamide with tetramethylthiuram disulfide.

(Continued)

UCLA TURF RESEARCH PROGRAM
UNDER V. B. YOUNGNER
TRANSFERRED TO RIVERSIDE CAMPUS

The turfgrass research activity centered at UCLA
since 1948 will be located on the Riverside campus of
the University of California after July 1, 1965. This move
is part of the phasing out of agriculture from the Los
Angeles campus which has been underway for the past
several years.

After completion of the move, an expanded research
effort at the new location will be effected. New facilities
now under construction for the Department of Agronomy
at Riverside will be used by the turfgrass research group
according to Dr. V. B. Youngner, who heads the turfgrass
program.

The work currently underway at the South Coast Field
Station, Santa Ana, will also become an activity of the
Department of Agronomy but will continue uninterrupted
at the Field Station under the immediate direction of
Mr. Stanley Spaulding, turfgrass technician.

Mr. Frank Nudge, laboratory technician, will remain
at Los Angeles for part of the summer to complete the
present work before joining the group at Riverside.
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<th>SUSCEPTIBLE GRASSES</th>
<th>CONDITIONS FAVORING DISEASE</th>
<th>CULTURAL CONTROL</th>
<th>FUNGICIDAL CONTROL*</th>
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<tbody>
<tr>
<td>BROWN PATCH</td>
<td><em>Rhioctonio solani</em> is a soil-inhabiting fungus, active as fine fungus threads that survive in the soil or in and on the turf. Hard masses of fungus threads (sclerotia) are very resistant to fungicides.</td>
<td>Bentgroses, Bluegrasses, Bermudas, Ryegrasses, Fescues</td>
<td>Excess thatch and mat, high temperatures (75° to 95° F), high humidity, and soft, lush growth due to excess nitrogen favor brown patch. A cold-weather (40 to 60 F) form of the disease occurs infrequently. Disease is more common in warm inland areas.</td>
<td>Reduce shading and improve soil aeration and water drainage. Water when needed to a depth of 8 to 12 inches if possible. Avoid nitrogen fertilization that results in soft growth of foliage.</td>
<td>PCN B, mercurials, thiram, Dithane M-45</td>
</tr>
<tr>
<td>DOLLAR SPOT</td>
<td><em>Sclerotinia homoeocarpa</em> fungus survives in the soil by means of sclerotia. Disease is common near or on the coast, essentially on bentgrass.</td>
<td>Bentgroses, Bluegrasses, Bermudas, Ryegrasses</td>
<td>Moderate temperatures (60° to 80° F) and excess moisture favor dollar spot. Turf deficient in nitrogen tends to develop more dollar spot than turf adequately fertilized with nitrogen.</td>
<td>Keep thatch at a minimum. Water only when needed to a depth of 8 to 12 inches. Apply adequate nitrogen.</td>
<td>cadmium, mercurials, cycloheximide, Dyrene, Dithane M-45</td>
</tr>
<tr>
<td>FUSARIUM PATCH</td>
<td><em>Fusarium nivale</em> probably over-seasons as a network of fungus threads in grass residues.</td>
<td>Bluegrasses, Ryegrasses, Fescues, Zoysia</td>
<td>Cool (40° to 60° F), moist conditions, such as prolonged rainy periods in winter, favor the disease. Usually appears first on shaded plants.</td>
<td>Reduce shade; improve soil aeration and water drainage. Avoid excess nitrogen fertilization.</td>
<td>mercurials, thiram, cadmium, Dyrene</td>
</tr>
<tr>
<td>MELTING OUT</td>
<td><em>Helminthosporium vagans</em> probably survives in infected bluegrass plants or debris as fungus threads and as spores. It may be seedborne.</td>
<td>Kentucky bluegrass, Improved selections, Merion and Newport, are resistant. Common Kentucky bluegrass is very susceptible.</td>
<td>Cool (50° to 70 F), moist conditions favor the disease. First appears on shaded plants. Most severe on closely clipped turf.</td>
<td>Reduce shade, improve soil aeration and water drainage. Do not mow grass lower than 1 1/2 inches.</td>
<td>captan, folpet, Dyrene, cycloheximid, Dithane M-45, Mercurials</td>
</tr>
<tr>
<td></td>
<td><em>H. cynodontis</em> probably survives in infected grass plants or grass debris as mycelium and spores. May be seedborne.</td>
<td>Bentgroses, Bluegrasses, Bermudas, Ryegrasses, Fescues</td>
<td>Warm temperatures (70° to 90° F) and high humidity favor the disease. First appears on plants growing in shaded areas. Most damaging on closely clipped turf.</td>
<td>As above</td>
<td></td>
</tr>
<tr>
<td>LEAF BLOTCH</td>
<td><em>H. cynodontis</em> probably survives in infected bermudagrass plants and debris as mycelium, and as spores. May be seedborne.</td>
<td>Bermudas, leaf blots damages young seedlings or adult plants weakened by factors such as excess thatch, deficient nitrogen, and unfavorable growing conditions.</td>
<td>Leaf blots damages young seedlings or adult plants weakened by factors such as excess thatch, deficient nitrogen, and unfavorable growing conditions.</td>
<td>Remove thatch at regular intervals. Apply adequate nitrogen.</td>
<td></td>
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</tbody>
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* USE AT RATES AND FREQUENCY RECOMMENDED BY MANUFACTURER.
<table>
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<tr>
<td>RED THREAD</td>
<td>Corticium udoforme over-seasons as pinkish or red gelatinous crusts of fungus threads. Disease occurs commonly along coast of northern and central California. It is rare in southern California.</td>
<td>Bentgrasses Bluegrass Fescues Ryegrasses</td>
<td>Red thread usually appears on plants deficient in nitrogen, and during periods of prolonged cool, wet weather.</td>
<td>Apply adequate nitrogen and reduce shading.</td>
<td>cadmium mercurials Dithane M-45 Dyrene</td>
</tr>
<tr>
<td>GREASE SPOT</td>
<td>Species of Pythium, mainly P. aphaniderma-um have thick, walled sexual spores that enable the fungi to survive in the soil for long periods. Infection by Zoospores (mobile spores) in water or by fungus threads.</td>
<td>All grasses</td>
<td>Grease spot usually appears in low spots that are wet for long periods. Disease depends upon excess moisture.</td>
<td>Reduce shading, improve soil aeration and water drainage. Water when needed to a depth of 8 to 12 inches,</td>
<td>zineb cycloheximide mercurials nabam Dexon</td>
</tr>
<tr>
<td>SEED ROT AND DAMPING OFF</td>
<td>Disease as caused by several species of Pythium, Rhizoctonia solani, Fusarium culmorum, and Helminthosporium sorokinianum.</td>
<td>All grasses</td>
<td>Seed rot and damping off are favored by excess water, sowing seeds of low viability, and sowing seeds above the recommended rates, especially during periods unfavorable for seed germination and growth.</td>
<td>Improve soil aeration and water drainage. Do not overwater. Sow only fresh, healthy seed at recommended rates and seasons</td>
<td>Treat seed with thiram, chloronil, and cycloheximide.</td>
</tr>
<tr>
<td>RUST</td>
<td>Puccinia striiformis and P. graminis over-season in infected grasses and as spores which are airborne.</td>
<td>Bluegrass Ryegrass</td>
<td>Moderately wound, moist weather favors rust development. Moisture in the form of dew for 10 to 12 hours is sufficient for spores to infect plants.</td>
<td>Keep plants growing rapidly by fertilization and irrigation</td>
<td>zineb maneb cycloheximide</td>
</tr>
<tr>
<td>FAIRY RING</td>
<td>Several species of mushrooms cause fairy rings. In northern and central California the predominant fungus is Marasmius oreades; in southern California, species of Leptota.</td>
<td>All grasses</td>
<td>Fairy ring develops most frequently in soil high in undecomposed organic matter.</td>
<td>Apply adequate nitrogen. Aerate soil for better water penetration.</td>
<td>Complete soil sterilization. Applications of organic mercurials may suppress mushroom production.</td>
</tr>
</tbody>
</table>

* WARNING: Pesticides are poisonous and always should be used with caution. Follow all precautions and safety rules on the label.

CAUTION: Chloropicrin and methyl bromide are very hazardous materials. Anyone using them or planning to use them should become familiar with and strictly follow the warnings on the package label or any accompanying material furnished by the manufacturer.

PHYTOTOXICITY: Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury also may result from excessive amounts or the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, dilluents, and solvents often can cause plant injury. Since formulations often are changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

**TURF FUNGICIDES**

**ME RCURIALS**

Organic

- hydroxy mercury chlorophenol: Semesan Turf Fungicide
- methyl mercury dicyandiamide: Panogen Turf Fungicide
- phenylmercury ethylenediamine: Lincks Lawn Fungicide
- phenylmercury monooctanol ammonium lactate: Pertaturf 10

PMA - phenyl mercury acetate: PMAS, Tag Fungicide, Scult, Tag-C-Lect, Phenmad, Liquiphene N-ethylmercuri - 1,2,3,6 tetrahydro-3, 6-endomethano 3,4,5,6,7,7-hexachlorophthalamimide: Emmi, SEC

Inorganic

- mercurous chloride (calomel) t mercuric chloride (corrosive sublimate): Calo-clor, Calogreen, Wood-Ridge Mixture 21, Fungchex, Calocure, Bi Cal, Velsicol 2-l Fungicide

**CADMIUM**

- cadmium carbonate: Ortho Lawn and Turf Fungicide, Ortho Lawn Fungicide
- cadmium chloride: Caddy, Cad-trete, Patterson's Liquid Turf Fungicide, Vi-cad
- cadmium copper zinc sulfate chromate complex: Mico Turf Fungicide C
- cadmium sebacate: Kromad
- cadmium succinate: Cadminate
- phenylamino cadmium dilactrate: Pertaturf 177

**ORGANIC**

- captan = N-trichloromethylmercaptop-4-cyclohexene 1,2-dicarboximide: Orthocide, Captan
- chloranil = 2,3,5,6-tetrachloro-1,4-benzoquinone: Spergon
- cycloheximide: Acti-dione R Z, Acti-dione-Thiram, Acti-dione ferrated
- dyrene = 2,4-dichloro-6-(O-chloranilino)-triazine: Dyrene, Turf-Tox D-50
- folpet = N-(trichloromethylthio) phthalimide: Phaltan, Ortho Lawn and Turf Fungicide
- maneb = manganese ethylene bisdithiocarbamate: Dithane M-22, Manzate
- PCNB = pentachloronitrobenzene: Fungiclor, Terraclor, Best Turf Fungicide
- polyethylenethiuramsulfide: Ethisul
- thiram = tetramethylthiuramdisulfide: Tersan, Panoram, D and P Turf-Tox, Thiramad, Thiuram 75
- zineb = zinc ethylene bisdithiocarbamate: Parzate, Dithane Z-78, Zineb

**COMBINATIONS**

- Acti-dione RZ = cycloheximide + PCNB
- Acti-dione-Thiram = cycloheximide t thiram
- Bandini Turf Fungicide = PCNB + PMA
- Cad-trete = thiram t cadmium chloride
- Kromad = thiram + cadmium sebacate + potassium chromate t malachite green + auramine
- Ortho Lawn Fungicide = captan + cadmium carbonate + insecticide and iron
- Ortho Lawn and Turf Fungicide = folpet, cadmium carbonate, thiram
- Scutl = PMA + thiram
- Tersan OM = thiram + hydroxy mercury chlorophenol
- Thimer = thiram + PMA
- Micro Turf Fungicide = thiram + cadmium calcium copper zinc sulfate
- Turf-Tox MC = thiram + mercuric chloride + mercuric chloride
- Mercuram = thiram + phenyl mercury dimethyldithiocarbamate + malachite green
- Thiuram M = thiram + mercuric chloride + mercuric chloride
- Fung-0-Cide = cadmium chloride + methyl mercury dicyandiamide + fertilizer

**SOIL FUNGICANTS**

- SMDC = sodium N-methylthiocarbamate: Vapam, VPM
- MIT = methylisothiocyanate: Vorlex (Vorlex is 20% MIT, 80% clorinated hydrocarbon)

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