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Diagnosis of Turfgrass Diseases: The Art and the Science

by Eric B. Nelson

Diseases are perhaps the most unusual and perplexing of the pest problems affecting highly managed turf. As a result, diagnosing problems that may be caused by disease represents one of the more challenging and frustrating exercises in turfgrass management.

Both weed and insect pests can be readily seen with the unaided eye. Insects or weeds, regardless of their stage of development, look much the same in any environment. In addition, being readily visible, they can be matched in appearance with the diagrams and photographs presented in books and other diagnostic reference aids.

Diseases, on the other hand, are caused by a wide variety of microscopic organisms, none of which is observable with the naked eye. And the activities of these pathogens can be seen only indirectly, by observing the responses of the turfgrass plants they have infected.

Diagnosis is complicated further by differences in the symptoms of infection by a particular pathogen, depending on factors such as the species of grass involved, the height of cut, local environmental conditions, or the presence of other pests and pathogens. Chemical, physical and biological stresses also affect the expression of symptoms.

Disease diagnosis can be thought of as a process of elimination, in which the range of potential causes for the observed problem is carefully reduced to one. The sequence of steps one follows in diagnosing turfgrass diseases is designed to assemble evidence for and against possible causes for the observed problem. It is important, therefore, that turfgrass managers maintain accurate and complete records of both site management activities and the season's weather. Combining these two data sets with careful observation of the turfgrass symptoms and examination of pathogen structures permits identifying associations between the disease and a causal agent.

Because they are perennial plants, turfgrasses develop long-term associations with pathogens. In fact, in nearly all mature turfgrass plantings, individual plants are continuously infected with many, if not all, of the pathogens capable of causing disease in that particular grass species. This is why symptoms of many turfgrass diseases are detected most often when turfgrass plants are under stress. Additionally, the presence of many turfgrass pathogens in a single sample complicates disease diagnosis by making it difficult to reduce the probable causes of the symptoms observed to a single agent.

*Photographs provided by Eric B. Nelson

IN THIS ISSUE

Considerable training and experience are required to overcome these difficulties and make competent disease diagnoses. Turfgrass managers therefore often turn to academic experts for assistance in the diagnostic process. This couples the manager's expertise in the field with the academic's expertise in the laboratory, facilitating both the determination of the cause of the problem and the selection and implementation of appropriate control measures.

Importance of correct disease diagnosis

Proper diagnosis is central to any successful turfgrass disease management program. There are several reasons for this. First, identifying the cause of any problem helps the turfgrass manager identify some of the conditions that may have fostered its development. In a sense, the diagnosis of disease itself helps the turfgrass manager understand more about the biology of the causal agents, and how to limit their impact.

Second, many contemporary disease control strategies are quite specific, being effective against one disease, ineffective against others, and potentially making still other diseases much worse. For example, the action of fungicides can be very narrow, affecting only certain groups of fungal pathogens. Inaccurate diagnoses could thus lead to the application of unneeded fungicides, which could have damaging side effects.

Third, the successful adaptation of Integrated Pest Management (IPM) scouting and monitoring protocols to the situation at hand depends on accurate identification of turfgrass pest problems. Identification is easily accomplished for weed and insect pests, but is problematic for diseases. Accurate diagnosis gives turfgrass managers the ability to map and measure specific disease problems so more effective control strategies can be developed and implemented. It also gives them the ability to gauge the effectiveness of control measures and aids in the prediction of future disease outbreaks.

Basic analytical processes in disease diagnosis

All disease diagnostic procedures follow a logical sequence of steps, designed to gather enough evidence to exclude potential causal agents from consideration. Both field and laboratory observations contribute to this process.

One of the first challenges to any turfgrass manager is to determine whether the observed problem in question is actually the result of disease. Disease symptoms often resemble damage from noninfectious agents (insects, for instance) or from a variety of abiotic problems (such as localized dry spots).

Sometimes, the characteristics of the damage can provide clues. The patch-like appearance of symptoms, usually easier to see on close-cut than on higher-cut turf, may be indicative of a disease problem. Most known turfgrass diseases are caused

Steps in Disease Diagnosis

In the field

1. Identify affected grass species and cultivars
2. Observe symptoms over the entire affected area
3. Observe specific plant symptoms
4. Make field observations of pathogen structures in turfgrass tissues
5. Record the cultural and environmental conditions
6. Attempt an initial diagnosis
7. Collect and submit samples for clinical diagnosis

In the lab

8. Laboratory examination of turfgrass samples
9. Pulling it all together into a final diagnosis

In the field

10. Select an appropriate management strategy

by fungi. Since fungi tend to grow outwards from the site of infection, many fungal pathogens cause circular, patch-like symptoms in turfgrass plantings. There are several turfgrass diseases, however, that do not typically induce patch symptoms. Symptoms of these diseases are commonly confused with signs of other turfgrass problems. The following are the steps one normally would go through in diagnosing these and other turfgrass diseases.

Step 1. Identify affected grass species and cultivars

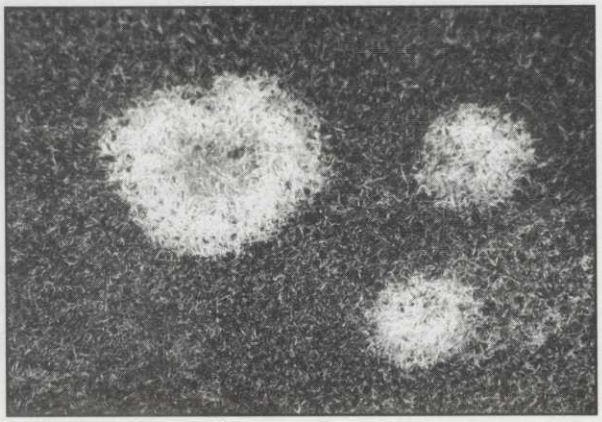
One of the first steps in any diagnosis is to determine which plants are affected. A number of turfgrass pathogens are relatively specific to particular turfgrass species. Some are even specific to individual turfgrass cultivars within a species. For example, take-all patch caused by *Gaeumannomyces graminis* var. *avenae* is generally found on creeping bentgrasses, but not on other turfgrass species. Similarly, summer patch disease caused by *Magnaporthe poae* is found on bluegrasses and fine fescues, but rarely, if ever, on perennial ryegrass varieties. Even within a turfgrass species, cultivars can vary in response to diseases. For example, varieties of Kentucky bluegrass such as Bristol, Eclipse and Glade are relatively tolerant of summer patch disease, to which varieties such as Chateau and Fylking are quite susceptible.

On golf courses where mixed stands of annual bluegrass and varieties of creeping bentgrass are common, the annual bluegrass tends to be affected more severely, or shows symptoms much earlier, than the creeping bentgrass variety. This can apply to root and crown diseases such as Pythium root rot caused by *Pythium graminicola,* anthracnose caused by *Colletotrichum graminicola,* and some nematode problems.

Turf affected in low-lying areas is suggestive of pathogens favored by wet conditions.

Symptoms occurring adjacent to concrete or pavement, which can raise soil temperatures, may indicate a disease favored by heat stress.

Areas experiencing heavy equipment traffic often show symptoms in regular patterns.



Patch-type symptoms are usually indicative of fungal diseases.

Step 2. Observe the entire affected area for symptoms

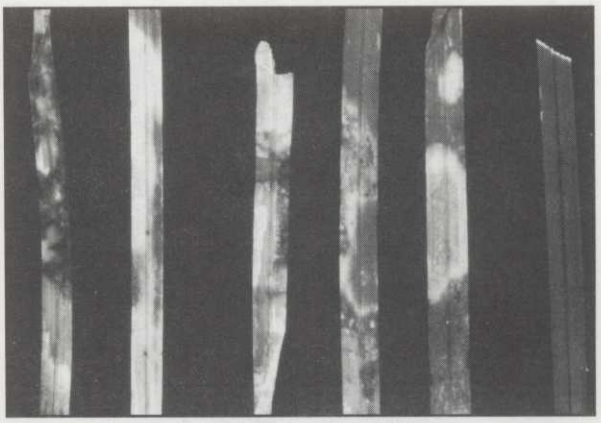
The location of symptoms in the affected area can reveal important information about the nature and distribution of the disease, since certain pathogens are usually associated with certain distribution patterns. For example, it is useful to know whether symptoms are restricted to wet, low-lying areas, or to high, dry areas. It would also be noteworthy if symptoms were limited to areas of intense foot or equipment traffic, or to areas of extreme soil compaction. Other important factors affecting symptom distribution are soil characteristics (such as texture and pH), the degree of shade, and the proximity of structures such as buildings, roads and sidewalks that may alter soil temperatures.

How symptoms appear can also reveal important information about diseases. For example, it is important to note whether the symptoms appear at random throughout the affected area, or are localized in discernible structures. Rather than appearing diffused throughout susceptible turfgrasses, some diseases usually appear as rings or patches. Root and crown diseases, for instance, generally give rise to more patch- or ring-like symptoms; foliar diseases, on the other hand, tend to result in more diffuse symptoms.

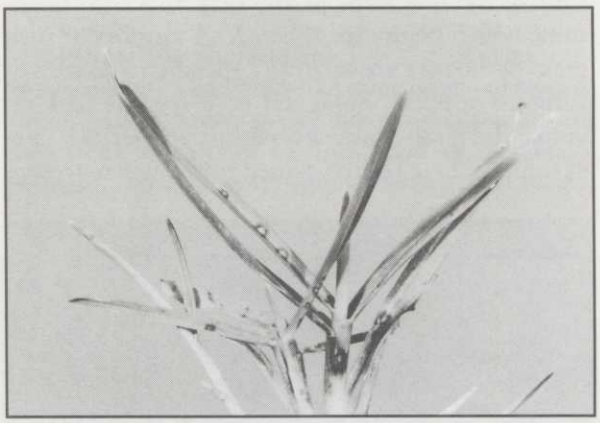
Disease symptoms that appear patch-like on close-cut turf may seem diffuse on higher-cut turf. Conversely, foliar diseases such as dollar spot and red thread may actually appear patch-like on both high-cut and close-cut turf.

Examining the whole set of symptoms at this stage of the diagnostic process will help to sort out whether the problem being observed is biotic or abiotic in origin. For example, if symptoms appear in a highly regular pattern, this may indicate a problem caused by maintenance equipment. An example would be the movement of equipment over heat-stressed turf. Overapplication of fertilizers or pesticides can also produce regular patterns. Examining turf at this stage might also reveal the presence of other noninfectious biotic factors such as insects, algae or moss that might be contributing to the observed problem.

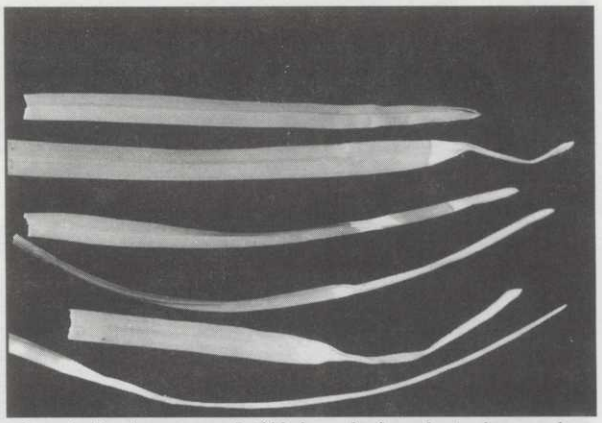
Often, when assessing symptoms, it is difficult to determine whether the problem under examination is currently active and worsening or has been inactive and stabilized for some time. This is particularly true of diseases such as red thread caused by *Laetisaria fuciformis*. On perennial ryegrasses and fine-leafed fescues, necrotic patches from red



Fungal pathogens often produce irregular leaf lesions.



Leaf-spotting pathogens tend to cause well defined, readily recognized lesions.



Some leaf pathogens cause leaf blades to die from the tip downward, producing tip blight.

thread can often be seen long after the pathogen has ceased to be active. Generally, the only way to tell whether the pathogen is still active is to get down on hands and knees and examine the turfgrass plants closely for the presence of progressive symptoms or pathogen structures. In the case of foliar diseases, the mycelium or other structures are sometimes visible when the pathogen is active or has recently been active. Where disease is concerned, fungal activity is difficult to assess.

Step 3. Observe specific plant symptoms

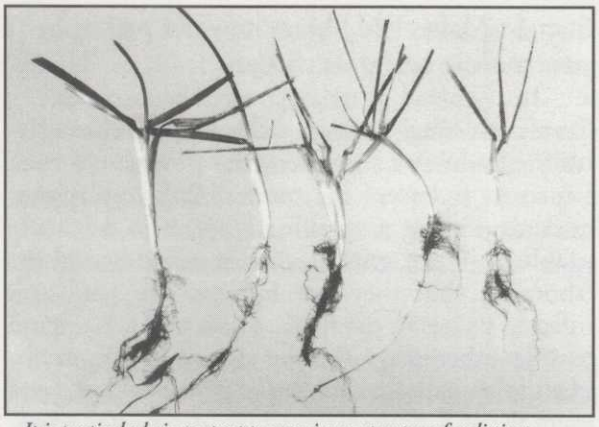
Specific symptoms on individual plants can provide still more information on the possible causes of disease problems. They are also one of the most important diagnostic features available for some diseases. The principal above-ground symptoms to look for are leaf spots. Pay particular attention to the appearance of the lesions. It is important, for example, to determine whether the lesions are irregular in shape or circular, and whether they have a yellow (i.e., chlorotic) halo or a purplish or brownish area on their borders.

Blighting, in which the plant, particularly the leaves, turns brown (i.e., necrotic), is another above-ground symptom to look for. With leaves, for example, it is important to note whether they appear to be blighting from the tip down, or from the basal stem upward.

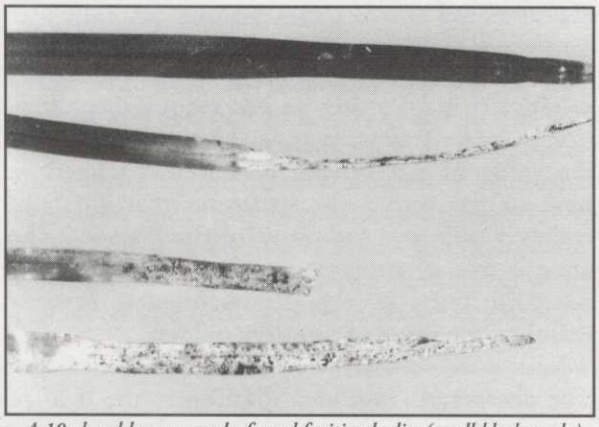
Other commonly observed above-ground symptoms include wilting, stunting and rotting. More specific observations about these symptoms should include such things as whether, during wilting or rotting, the plants appear dry or wet and greasy.

In addition to the character of specific plant symptoms, it is important to note which individual plant parts are affected. Blighting symptoms may appear on leaf blades or sheaths, for example. Rots may appear on sheaths, roots and rhizomes. Rotting symptoms are found most often on below-ground plant parts.

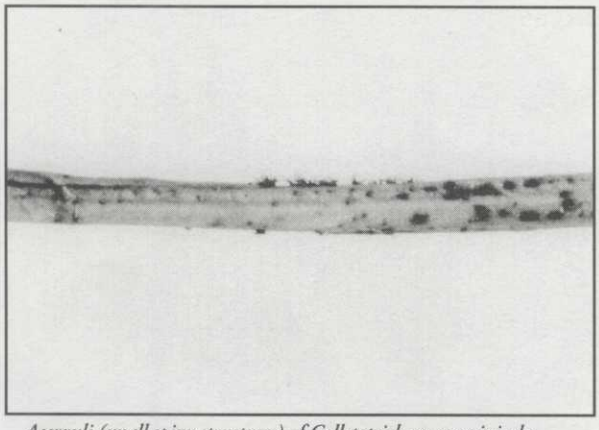
Examination of the root system deserves equal attention in disease diagnosis, noting abnormalities such as discolorations, deformations, distinct lesions and absence of root hairs. When removing individual plants for root inspections, it is extremely important to keep as much of the root system as possible intact. The article on root and crown disease diagnosis in this issue of *TurfGrass TRENDS* provides additional information on this important aspect of the diagnostic process.



It is particularly important to examine root systems for distinct lesions, the absence of root hairs, or non-specific root and crown rotting.



A 10x hand lens can make fungal fruiting bodies (small black specks) visible in diseased tissues.



Acervuli (small spiny structures) of Colletotrichum graminicola observed on partially living tissue are particularly diagnostic for Anthracnose.

Step 4. Make field observations of pathogen structures in turfgrass tissues

Since most fungi are identifiable by their characteristic reproductive structures, the presence of such structures is one of the more definitive pieces of evidence linking a specific pathogen to a specific problem. These structures are observed best in the laboratory, but they can be seen frequently on infected tissues in the field. The use of a 10x hand lens or other magnification device is a must for identifying pathogen structures in the field. A good example of a disease for which diagnostic reproductive structures may be seen under low magnification is anthracnose, caused by *Colletotrichum graminicola.*

During disease development, some pathogens produce structures that do not require magnification to be seen. For example, *Laetisaria fuciformis,* the cause of red thread, produces characteristic pink to red thread-like structures that are both readily visible and indicative of the disease. The same is true of pathogens such as *Typhula incarnata,* the cause of Typhula blight, and *Erysiphe graminis,* the cause of powdery mildew.

The observation and identification in the field of pathogen structures can accelerate the diagnostic process significantly. Since these structures tend to be short-lived, their presence can indicate how recently the pathogen has been active.

Step 5. Record the cultural and environmental conditions

Recording the cultural conditions before and during the onset of disease symptoms is an important part of the evidence-gathering process. The same holds true for the environmental and weather conditions immediately preceding the onset of symptoms. Both can quickly eliminate certain possible pathogens from consideration as causal agents.

Among the cultural conditions it is important to record are the age of the turfgrass planting and the specific fertilization, irrigation and pest control practices employed (including materials and amounts applied). Grooming and growth management practices should be noted as well; so should any peculiarities such as increased traffic, excessive thatch, unusual soil odors and the like. Where appropriate, unusual features of the landscape should be noted. These might include the presence of large trees or roots in and around the affected site, shading, air and water drainage and soil pH.

The important items of weather information to record are: maximum and minimum daily temperatures, relative humidity, rainfall, degree of cloud cover and wind speed. Obviously, the most appropriate weather data would be those collected at the affected site. National Weather Service data can also be used if a recording station is located close enough to the site to provide representative readings.

Step 6. Attempt an initial diagnosis

Once all the pertinent field information has been gathered, a tentative diagnosis is in order. Numerous guides have been written to aid in the diagnosis of turfgrass diseases. Disease identification manuals may be available from the state's land grant universities. Similar manuals may be available from pesticide and fertilizer manufacturers, the federal government, private consultants, professional turfgrass associations and scientific societies. There are also textbooks devoted exclusively to turfgrass diseases (a list of 10 accompanies this article). If no clear diagnosis can be reached after making observations, examining the cultural and environmental data and consulting the manuals, then the next step in the process is to enlist the help of a competent laboratory diagnostician.

Step 7. Collect and submit samples for clinical diagnosis

To ensure that the laboratory diagnostician has all the information required to make an accurate diagnosis, it is important to collect a proper sample and send it along with the appropriate field observations. Turfgrass samples with apparent aboveground or below-ground symptoms should be collected as early as possible after the onset of the disease, preferably as the problem is on the increase. Samples collected long after the problem was first noted can be difficult to diagnose accurately.

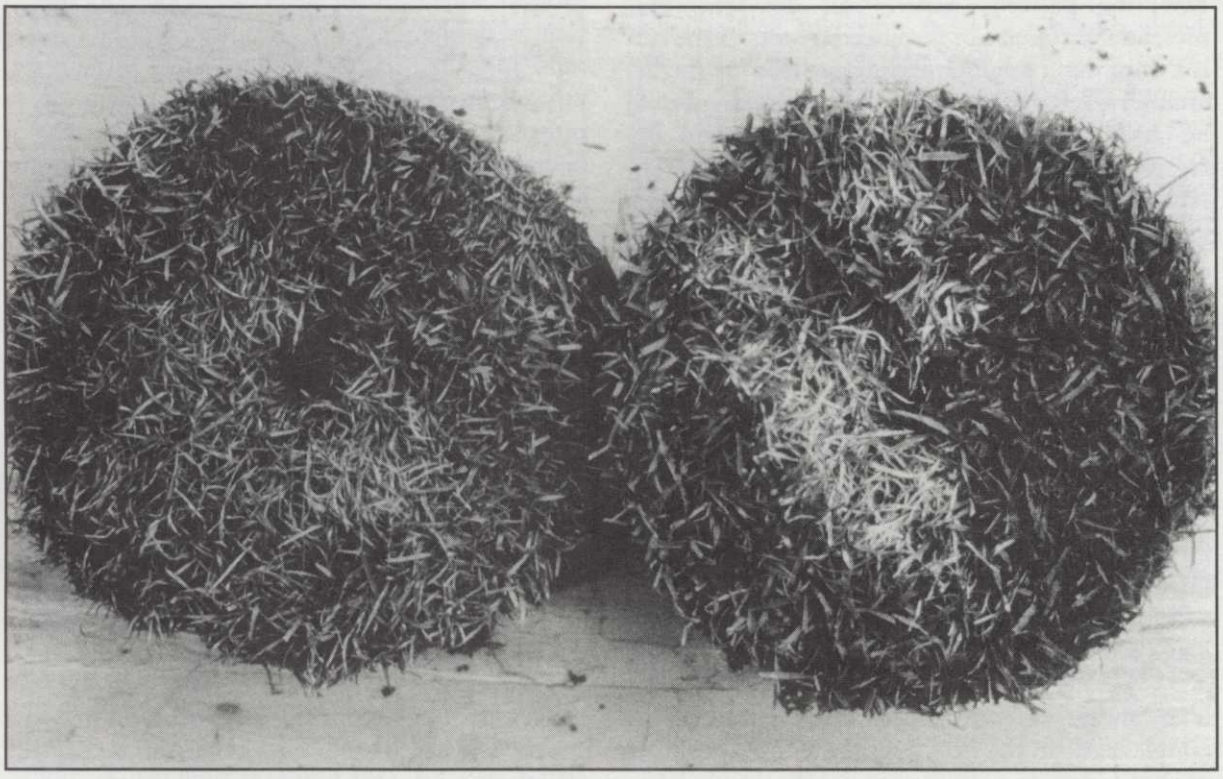
The samples collected should be representative of the symptoms observed over the entire affected area. Since the clinical diagnostician does not have

the luxury of observing the problem first hand in the field, it is critical that the sample be accompanied by an adequate description of the problem, a record of the cultural practices and a description of the environmental and weather conditions that were present at the time the problem was first observed. The following critical information should be included with the sample:

- The grass species. If known, the precise cultivars.
- A description of the overall symptoms, the date they first appeared and the extent of the affected area. Be specific about symptom location and appearance.
- A description of the cultural conditions before and during the onset of symptoms.
- A description of the weather conditions before and during the onset of symptoms.
- If possible, a photograph of the affected area (Polaroid is fine).

To facilitate comparison in the laboratory, samples should be collected both from the turf showing symptoms and from apparently healthy turf. In addition, samples should not be collected shortly after a fungicide has been applied. Generally, if the fungicide is effective against the suspected pathogen, it will have done its work before the sample can be analyzed, making meaningful diagnosis impossible.

If symptoms are patch-like, take the sample from the edge of the patch, making sure it contains both healthy and diseased turf. This allows the diagnostician to watch the disease progress in the laboratory. If symptoms are diffuse, take two samples: one from the diseased area and one from a nearby area that appears healthy. Even though many turfgrass pathogens are readily identified in both healthy and diseased turf, having samples of both helps eliminate some pathogens as the primary disease-causing agents, since the relative abundance of a causal agent may be greater in a diseased specimen than in a healthy turfgrass specimen. Turf collected from golf courses may be sampled with a cup cutter and need only be removed to a depth of



Golf course cup cutter plugs make ideal samples for diagnostic laboratories. Both healthy and symptomatic turf should be included.

two to three inches. If a cup cutter is not available, use a knife to cut a 6″x 6″ piece of sod. Sample from both symptomatic and apparently healthy areas as described above.

Packaging the sample for shipment to a diagnostic laboratory is critical. If the sample is relatively moist, wrap it in newspaper or aluminum foil, and place it in a cardboard box for mailing. If the sample is dry, moisten it slightly, wrap, pack and mail as described above. Avoid wrapping samples in plastic or plastic bags since these materials retain moisture in the sample and encourage many different organisms to grow, possibly masking important symptoms. Avoid exposure to heat or direct sunlight.

Sometimes, nematodes and the problems they cause must be taken into consideration in disease diagnosis. If nematodes are suspected as the cause of a problem, it is best to sample from both healthy and symptomatic areas. The most appropriate times to obtain such samples are in the spring, about a month after the turf greens up, and in the autumn, when turf may be more symptomatic.

Sampling patterns depend on the symptoms present and the size of the affected area. If the turf is exhibiting a gradual decline, a series of smaller samples—referred to here as subsamples—should be taken randomly throughout the area (in a zigzag pattern, for example). A minimum of six subsamples should be taken from an area that is one half-acre (~21,000 ft.2) in size. If symptoms appear in patches, subsamples should be taken just inside the periphery of the patch.

All sampling should be done to a depth of approximately four inches. Subsamples may be taken with a cup cutter, a 1″ soil sampling probe, or a trowel. Subsamples should be mixed together, placed in a plastic bag and shipped immediately. Avoid exposure to heat or direct sunlight. It is best NOT to moisten samples believed to contain nematodes. Further details about specific nematode problems and their diagnosis will be published in future issues of *TurfGrass TRENDS.*

It is always best to collect and mail turfgrass samples early in the week, so they do not spend the weekend in a post office or at the diagnostic laboratory. It is always helpful to telephone the diagnostic lab before sending the sample to make sure that the diagnostician is prepared to receive and process the sample quickly. This is particularly important during the busiest months of the season (June, July and August). Whenever possible, send samples to the diagnostic laboratory using an overnight delivery service (Federal Express or Airborne Express, for example). See the list in this issue of *TurfGrass TRENDS* for the addresses of diagnostic laboratories in the United States and Canada.

Step 8. Laboratory examination of turfgrass samples

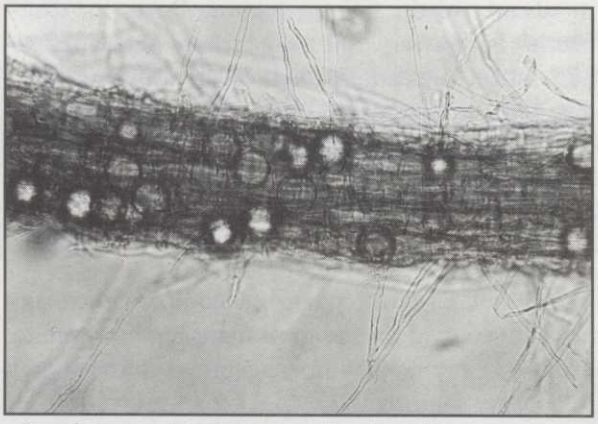
Closely examining turfgrass samples, whether in the field or in the laboratory, is a critical part of nearly all disease diagnosis. It serves as a means of verifying initial diagnoses based on field observations. In addition, in the case of some diseases, it provides the only means of definitively identifying the cause of the problem. The purpose of close laboratory examination is to find physical evidence for the presence of the causal agent(s).

Nearly all fungi causing diseases in turfgrasses produce characteristic structures, reproductive as well as nonreproductive, in affected plants. Since most fungal structures are not visible without significant magnification, the clinical diagnostician must use a microscope to examine them. Generally, two types of microscopes are used in the analysis of turfgrass specimens: a dissecting microscope for examining whole plants and plant organs, and a compound microscope for observing tissues and cells. Observation and classification of the fungal reproductive structures allow the diagnostician to more accurately identify the active pathogens.

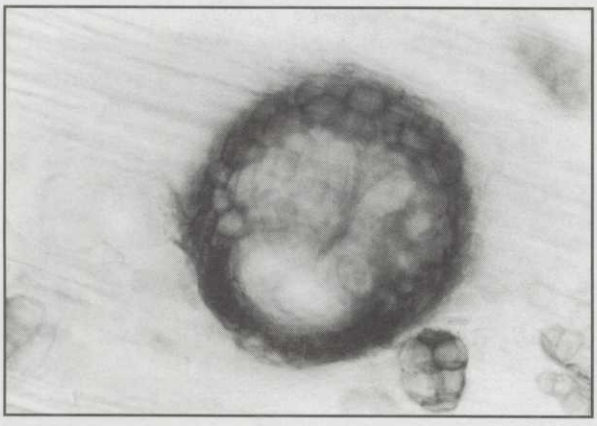
The structures for which diagnosticians look include: characteristic spore shapes, sizes and colors; unique mycelial shapes and structures; sclerotia; and fruiting bodies such as pycnidia, acervuli, and perithecia. The diagnostician must also check for the presence of other causal agents such as bacteria, viruses, algae and nematodes.

In some cases, no fungal structures may be apparent when tissues are observed under the microscope. In this case, leaf, sheath or crown tissues are incubated in a high-humidity chamber to encourage whatever fungal pathogens may be

After incubating a sample affected by brown patch in a high humidity chamber, the mycelium of the pathogen is readily visible.



Fungal structures in turfgrass organs (here is a turfgrass root containing oospores of Pythium spp., the cause of Pythium root rots) are visible under the microscope.



Microscopic examination of turfgrass tissues (this is a perithecium of a Leptosphaerulina species causing a foliar blight of Kentucky bluegrass) reveals additional fungal structures.

present to grow in a mycelial form or sporulate, revealing their reproductive structures for identification. These fungal tissues may then be transferred to laboratory culture media for further observation or examined under the compound microscope. However, since many different microbes on or in affected turfgrass tissues can grow and reproduce in this environment, the diagnostician may find evidence of several different fungal pathogens, along with a myriad of nonpathogenic or saprophytic fungi and other microorganisms.

If physical evidence of a pathogen cannot be found in turfgrass tissue, other methods for detecting and identifying pathogens may be used. The most common backup method for pathogen detection and visualization is isolation of the potential pathogen from the turfgrass tissue. Most fungal turfgrass pathogens can be readily grown on laboratory culture media. A few turfgrass pathogens are obligate parasites—in other words, constrained to living in a certain manner—which makes them difficult to culture. The latter include: *Puccinia* and *Uromyces* spp. causing rust diseases; *Erysiphe graminis* causing powdery mildew; and *Sclerophthora macrospora* causing yellow tuft disease. Once a pathogen has been cultured successfully in the laboratory, its growth and reproductive habits can be observed in detail and its physical appearance compared with what was observed in the diseased tissue.

Over the past few years, even more sophisticated methods of pathogen detection have been developed. These include immunological techniques that use pathogen-specific antibodies to detect the presence of specific pathogens in turfgrass tissues. More recent developments include methods for the analysis of pathogen DNA in the host tissue. These are similar to the blood DNA analysis currently used in criminal trials. Such techniques represent some of the most sensitive and accurate methods available for identifying particular pathogens and may prove to be the only means of confirming that the suspected pathogen is, in fact, the primary disease-causing agent.

In the event that no evidence of fungal pathogens can be found, the problem is either not a result of disease, or if it is the result of a disease it can only be the product of a nonfungal pathogen. The latter would include viruses, bacteria, and nematodes. The problem could also be caused by abiotic agents, or by noninfectious biotic agents such as algae, mosses, insects or rodents.

Step 9. Pulling it all together into a final diagnosis

Once all the pertinent information from field and laboratory has been assembled, the clinician faces the difficult task of interpreting all of the evidence and coming up with an accurate diagnosis. It should be noted that, while the process of assembling diagnostic evidence is rigorous, converting that evidence into a diagnosis is more art than science. Making the actual diagnosis is the most critical step in the educated guessing that goes on in this process.

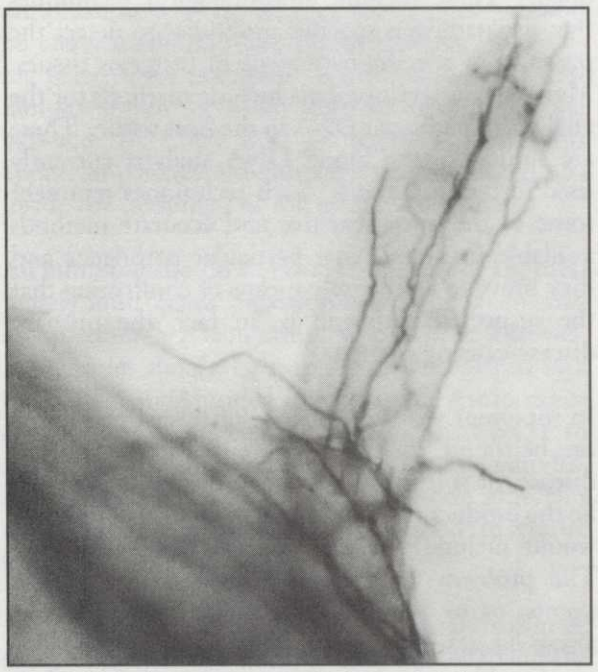
Sometimes the evidence available is either incomplete or inconclusive. In this case, further field observations, followed by another round of clinical examinations, may be warranted. In most cases, however, a diagnosis will prove possible.

Particularly in difficult cases, the diagnosis may hinge on the results of the laboratory examination. As is frequently the case, however, the clinical diagnostician may find evidence of two or more pathogens in the diseased specimen. Here is where the cultural and environmental information accompanying the sample becomes critical and must be evaluated together with the clinical observations to further narrow the range of possible causes. A diagnostician's ability to make accurate diagnoses is based primarily on his or her knowledge of specific diseases, the factors affecting their causal agents, and the pathogens themselves. Numerous written resources, in addition to those noted previously, are available to aid the diagnostician.

Diagnoses may be reported to the turfgrass manager in a variety of ways. Most often, a written report identifying the pathogen(s) believed to be the primary cause(s) of disease(s) is sent directly to the person who submitted the sample. Sometimes, to permit timely intervention to control a problem, the diagnosis will also be transmitted by telephone in advance of the written report. Prices for diagnostic services vary, but are generally in the $25 to $75 range, depending on the laboratory and the detail of the diagnosis.

Step 10. Select an appropriate management strategy

Recommendations frequently accompany the diagnosis. It is up to the turfgrass manager, however, to select an appropriate management strategy and implement it properly.



Ectotrophic hyphae growing on root surfaces can be indicative of a patch disease.

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Errata

On page 6 of the June 1995 issue of *TurfGrass TRENDS*, the term "Hyphae" is misspelled "Nypae."