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D I S E A S E P A T H O L O G Y

Predicting Rhizoctonia blight with 'risk models'

By Michael A. Fidanza, Ph.D.

Rhizoctonia blight (formerly called "brown patch") was one of the first turfgrass diseases to be identified, described, and investigated at the turn of this century (1,2,4). In cool-season turfgrasses, Rhizoctonia blight is associated with hot and humid weather common during the summer months (Fig. 1, 2). Therefore, early investigations into Rhizoctonia blight focused on identifying the weather conditions associated with this disease.

In 1930, a University of Massachusetts researcher, L.S. Dickinson, was the first to observe the environmental conditions associated with Rhizoctonia blight (2). He noted that Rhizoctonia blight disease symptoms often appeared on creeping bentgrass when the afternoon air temperature ranged from 80- to 90°F. A researcher with the U.S. Department of Agriculture, A.S. Dahl, followed-up on Dickinson's work by examining air temperatures and Rhizoctonia blight development at the Arlington Turf Gardens (currently the site of the Pentagon building in Arlington, VA). Over five consecutive summers, Dahl observed that the disease occurred on 82% of those days from June through September when the daily minimum air temperature was >70°F (1). Unfortunately, Rhizoctonia blight disease or weather data were not included in his report.



Fig. 1. A circular ring of mycelium of *Rhizoctonia solani* infecting perennial ryegrass mowed at fairway height.

More than 60 years after Dickinson and Dahl published their observations, another researcher at the University of Massachusetts, Dr. Gail Schumann, launched an additional investigation into the environmental conditions associated with Rhizoctonia blight (5). As a result, a weather-based Rhizoctonia blight "risk model" was developed. (Note: the term "model" as defined by Webster's dictionary means "a hypothetical description, often based on analogy, used in analyzing something". With weather-based plant disease prediction methods, the term "model" is a name for a mathematical equation or set of rules which are used to describe the specific environmental con-

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ditions required for a disease to occur). In the recent work at the University of Massachusetts, the following environmental conditions were identified as being conducive to *Rhizoctonia* blight development on creeping bentgrass: relative humidity 95% for a duration of 10 hours; rainfall of 1 inch within 36 hours; minimum air temperature of 59° F; average air temperature of 68° F; minimum soil temperature of 64° F; and average soil temperature of 70° F.

These environmental parameters are considered a "model" for predicting the "risk" of a *Rhizoctonia* blight occurrence. In other words, under those specific environmental conditions, the chance or risk of experiencing a *Rhizoctonia* blight problem is considered "favorable" or "very-high".

The "model", composed of the set of environmental "rules" listed previously, was evaluated by researchers in Massachusetts, New Jersey, and Georgia for its ability to predict *Rhizoctonia* blight (5). Disease development was based on increases in blight symptoms, and was predicted with an average of 81% accuracy for all three sites over two seasons. An important attribute was added to this model: a *Rhizoctonia* blight warning or risk alert was cancelled if air temperatures decreased below 59° F following a favorable disease forecast. As a result, these environmental conditions were incorporated into commercially available weather stations that included *Rhizoctonia* blight disease prediction programs. Next, researchers in Maryland developed a mathematical method to relate a combination of environmental conditions with *Rhizoctonia* blight (3).

Rhizoctonia blight warning model: materials and methods. The study site was located at the University of Maryland Turfgrass Research Facility in Silver Spring,

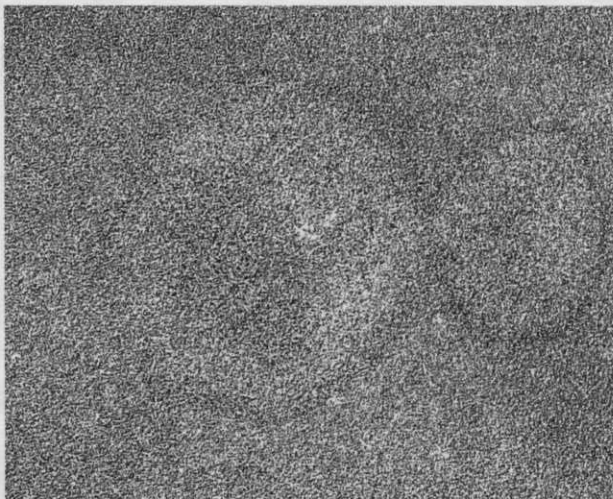


Fig. 2. Note the characteristic "smoke-ring" symptoms of *Rhizoctonia* blight, commonly observed on closely-mowed putting greens.

MD. Environmental conditions and the occurrence of *Rhizoctonia* blight were evaluated in a mature stand of perennial ryegrass turf from June 1991 through August 1993. Perennial ryegrass was chosen because of their extensive use as fairways in Maryland and other transition-zone areas, and because perennial ryegrass is extremely susceptible to *Rhizoctonia* blight.

The environmental conditions were monitored, measured, and recorded with several sensors that were attached to a datalogger. The environmental conditions measured were summarized into 15 variables, and all variables were summarized in a 24-hour interval beginning and ending at 6:00 am. This interval was chosen because the mycelium of *R. solani* invariably develops in the turfgrass canopy at night (corresponding to hot and humid conditions, especially within the turfgrass canopy). The environmental variables measured were: mean relative humidity; hours of relative humidity >90% or >95%; hours of leaf wetness duration; total rainfall during the 24 or 48 hours prior to 6:00 am; minimum, mean, and average air temperature; minimum, mean, and average soil temperature; mean soil water potential; and mean and maxi-

mum solar radiation.

Rhizoctonia blight outbreaks were determined visually by noting the presence of *R. solani* mycelium infecting the turfgrass foliage. The study site was monitored daily between 7:00 and 8:00 am for the presence of foliar mycelium. Whenever mycelium was present, it was confirmed microscopically to ensure it was *R. solani* (Note: a discussion on detecting the *R. solani* pathogen in turfgrasses is included in this issue).

Environmental data and disease outbreak observations were subjected to intense statistical scrutiny (for example, correlation analysis, chi-square analysis, analysis of variance, and multiple regression techniques) to identify key environmental variables or conditions associated with disease development. As a result, it was determined that the best way to relate the many environmental conditions with disease development was through the creation of a "disease favorability index". Therefore, an "environmental favorability index" or "EFI" was developed to provide a warning of Rhizoctonia blight occurrence in turfgrasses.

Through multiple regression analysis of the data, mean relative humidity and minimum air temperature provided the best and simplest model for accurately predicting the EFI, and therefore for providing an accurate Rhizoctonia blight warning. An objective of this research was to develop a disease prediction method that was simple, accurate, and practical. For example, information regarding the length of leaf wetness duration, hours of continuous relative humidity >90%, and rainfall events were helpful to determine the EFI. However, leaf wetness sensors were difficult to calibrate and required a high level of maintenance, which was not considered practical for today's greenskeeper. In another example, the mean relative humidity over a 24-hour period was highly correlated with continuous hours of relative humidity >90% or >95%. Therefore, the mean relative humidity in a 24-hour period could be used to accurately account for those humidity variables measured in this research. Also, air temperature and relative humidity are easy and convenient to measure and record with today's technology in weather stations, or with weather satellite data downloaded to a



Fig. 3. Commercially-available weather station with built-in pest prediction models or pest alert programs.

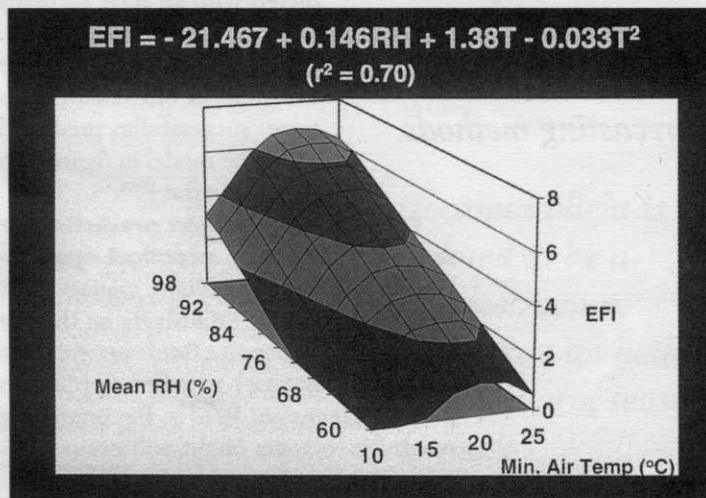


Fig. 4 A three-dimensional representation which depicts how relative humidity and minimum air temperature are related to the development of Rhizoctonia blight in turfgrasses. For example, conditions are favorable for disease development if the mean relative humidity and minimum air temperature combine to form an EFI (environmental favorability index) of >6.

computer terminal. Therefore, air temperature and relative humidity were the two environmental variables used to develop the EFI for predicting Rhizoctonia blight.

Results of model development

The air temperature and mean relative humidity information were combined to form the EFI (Fig. 4). At first glance, the mathematical equation or model shown in figure 6 may look complicated or

Advances in computer technology and the availability of weather information should lead to improved forecasting methods.

intimidating. The mathematical equation is also represented in figure 6 as a three-dimensional picture. Basically, the model is an academic way of showing a relationship between the hot and humid weather conditions that are favorable for Rhizoctonia blight development. The EFI is a simple way to determine a Rhizoctonia blight warning based on the complex relationship between air temperature and relative humidity. For example, an EFI of 6 indicated that the environmental conditions were highly favorable for a disease outbreak. As a result, Rhizoctonia blight outbreaks were predicted with an 85% accuracy over a three-year period. However, all major Rhizoctonia blight outbreaks were successfully predicted using the model in figure 6 to determine the EFI.

A Rhizoctonia blight prediction or warning method: practical applications:

Rhizoctonia blight management has focused almost exclusively on the use of fungicides since the Bordeaux mixture (CuSO₄ plus lime) was first applied to putting greens in 1917. By predicting when Rhizoctonia blight will occur, turfgrass managers may be able to use this information to proper time and target disease management strategies. Therefore, to determine the practicality of the EFI "model" for predicting Rhizoctonia blight, it was tested in a fungicide efficacy study conducted on both perennial ryegrass and colonial bentgrass (3).

In both turfgrass species, there were equal levels of Rhizoctonia blight control in turfgrass plots treated with a fungicide applied when an EFI warning was issued, and in turfgrass plots treated with a fungicide according to a 14-day calendar-based spray schedule. With the EFI-based spray schedule, however, there were five fungicide applications made during the summer months versus seven with the calendar-

based spray schedule. In this one year field trial, using weather-based information to predict Rhizoctonia blight and guide fungicide spray decisions resulted in a reduction in the number of fungicide applications without compromising disease control. A weather-based disease prediction method may help reduce fungicide sprays during certain years, however, more fungicide sprays may be called for in high disease pressure years (Note: a list of fungicides commonly used for Rhizoctonia blight management is included in this issue).

For a Rhizoctonia blight outbreak to occur, there must be a continuous interaction between the turfgrass host and the environment, where the environmental conditions favor the *R. solani* pathogen's growth and development over that of the susceptible turfgrass host. For turfgrass disease management, knowledge of the pathogen, environment, and host are critical to implementing successful control strategies and programs. A key component with Rhizoctonia blight management in turfgrasses is to utilize cultural practices that promote healthy and vigorous turf and thereby reduce disease severity. Also, proper timing and targeting of fungicide applications can be achieved through the use of weather-based disease prediction models and methods.

Advances in computer technology and the availability of weather information (for example, satellite imagery of regional and local weather patterns) should lead to improved disease forecasting methods. Satellite imagery also will be useful for enhancing the precise delivery of fungicides, biological agents, and other materials for enhancing turfgrass quality and managing turfgrass diseases. Future research will focus on both new technology and traditional approaches for improving turfgrass disease management programs.

References:

1. Dahl, A.S. 1933. Effect of temperature on brown patch of turf. *Phytopathology* 23:8.
2. Dickinson, L.S. 1930. The effect of air temperatures on the pathogenicity of *Rhizoctonia*

- solani* parasitizing grasses on putting-green turf. *Phytopathology* 20:597-608.
3. Fidanza, M.A., P.H. Dernoeden, and A.P. Grybauskas. 1996. Development and field validation of a brown patch warning model for perennial ryegrass turf. *Phytopathology* 86:385-390.
 4. Monteith, J. 1926. The brown-patch disease of turf: its nature and control. *Bulletin of the Green Section of the USGA* 6:127-142.
 5. Schumann, G.L., B.B. Clarke, L.V. Rowley, and L.L. Burpee. 1994. Use of environmental parameters and immunoassays to predict Rhizoctonia blight and schedule fungicide applications on creeping bentgrass. *Crop Prot.* 13:211-218.

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Rhizoctonia blight disease in turfgrasses, described

The soil-inhabiting fungus, *Rhizoctonia solani*, is responsible for causing numerous diseases of plants worldwide and under diverse environmental and ecological conditions. Historically, a French mycologist, De Candolle, first described the genus *Rhizoctonia* in 1815. However, a German mycologist, Kuhn, is credited with naming the fungus because of his early work on the ability of *R. solani* to cause disease on cultivated plants. Today, *R. solani* is pathogenic to over 200 grass species worldwide and is the causal agent for Rhizoctonia blight (formerly called "brown patch") in

turfgrasses.

Rhizoctonia blight is considered to be a highly destructive, foliar disease on both cool- and warm-season turfgrasses. The disease was first described from observations made in 1913 on a creeping bentgrass putting green near Philadelphia, PA. At that time, the disease was named "brown patch", however, turfgrass pathologists recently changed the name to Rhizoctonia blight. Further observations on Rhizoctonia blight were recorded from field work con-

Rhizoctonia blight is considered to be a highly destructive, foliar disease on both cool- and warm-season turfgrasses.



Fig. 1. Mycelium of *Rhizoctonia solani*, the causal agent of Rhizoctonia blight, infecting perennial ryegrass. This is referred to as a "sign" of the pathogen.

ducted by U.S.D.A. scientists in the 1920's and 1930's. These early investigations led to the development of the science of turfgrass pathology and turfgrass disease management.

The biology and lifecycle of *R. solani* as a turfgrass pathogen is well documented. The fungus survives as thick-walled mycelial masses during periods when environmental conditions are unfavorable for fungal growth. These mycelial masses are called sclerotia or bulbils, and they



Fig. 2 With Rhizoctonia blight, leaf lesions are commonly observed on wide blade turfgrass such as tall fescue.



Fig. 3. A circular ring of blighted turfgrass, which is a characteristic symptom of Rhizoctonia blight on a bentgrass putting green.

reside in the upper layers of soil, thatch, and plant debris. The bulbils are very difficult to see with the naked eye. They may germinate over a temperature range of 45 to 105°F, with an optimum germination temperature of about 80°F.

The optimum temperature for infection and disease development varies among turfgrass species and *Rhizoctonia* biotypes (referred to as "anastomosis groups"). The fungus is capable of saprophytic growth in

soil – meaning that the fungus can survive from dead, decaying organic matter. When the bulbils germinate, the fungus spreads radially in the upper soil surface or thatch to form a roughly circular colony.

During warm, moist and humid conditions, typically from late spring through late summer, the fungus can spread over the soil and up onto moist turfgrass sheaths and leaves. Gray- to white-colored fungal mycelium form an infection cushion, which penetrates the leaf tissue causing cell contents to ooze-out into intercellular spaces. Visual observations of the fungal mycelium infecting the turfgrass are referred to as a "sign" of the fungal pathogen (figure 1). Infected leaf tissue appears water-soaked and darkened. Turfgrass leaves then wilt and turn brown upon exposure to sunlight or a drying wind. When plant tissues decompose, bulbils can form again on or in dead tissues, and are released into the thatch and soil.

Rhizoctonia blight symptoms vary depending on turfgrass species and cultivar, level of turfgrass maintenance, soil and environmental conditions, and *Rhizoctonia* biotype. Infected turfgrass will display roughly circular patches of blighted and necrotic foliar tissue. Tan lesions with dark borders, where necrotic and green tissue meet, are sometimes evident on diseased leaves (Fig. 2).

In cool-season turfgrasses, *Rhizoctonia* blight is favored by periods of warm, humid, and moist environmental conditions. On closely mowed cool-season turfgrasses (for example, a bentgrass putting green or fairway height turfgrass), circular or irregular-shaped patches of blighted turfgrass are commonly observed (Fig. 3). A darkened, grayish-black border at the patch margin is called a "smoke-ring", and may be evident during the early morning hours. The "smoke-ring" is a sign that reveals the presence of mycelium actively infecting the leaf tissue, as indicated by water-soaking of leaves on closer, visual inspection (Fig. 4). On high-cut cool-season turfgrasses (for example, the fine fescues, Kentucky bluegrass, perennial ryegrass, and tall fescue), a

light brown, circular patch of blighted leaf tissue is the primary symptom and patches often appear without a "smoke-ring" (Fig. 5). Leaf lesions are easily detected on wide leaf blades (for example, tall fescue), and often fungal mycelium can be observed covering wet leaves during the early morning hours.

On warm-season turfgrasses (for example, bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass), blighted patches commonly are observed in the spring when these grasses break dormancy, or in the fall as they approach dormancy. Leaf sheath and basal rots are associated with *Rhizoctonia* blight in warm-season grasses.

References:

Burpee, L.L. and S.B. Martin. 1996. Biology of turfgrass diseases incited by *Rhizoctonia* species. pp. 359-368. In B. Sneh, S. Jabaji-Hare, S. Neate, and G. Dijkstra (eds) *Rhizoctonia* species: taxonomy, molecular biology, ecology, pathology and disease control. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Couch, H.B. 1995. Diseases of turfgrasses. Krieger Publishing Company, Malabar, FL.

Smiley, R.W., P.H. Dernoeden, and B.B. Clarke. 1992. Compendium of turfgrass diseases. APS Press, St. Paul, MN.

Vargas, J.M. 1994. Management of turfgrass diseases. CRC Press, Boca Raton, FL.

Watschke, T.L., P.H. Dernoeden, and D.J. Shetlar. 1995. Managing turfgrass pests. CRC Press, Boca Raton, FL.



Fig. 4. Notice the *Rhizoctonia solani* mycelium active on the patch margins in this fairway height perennial ryegrass.



Fig. 5. *Rhizoctonia* blight symptoms observed on Kentucky bluegrass.

TurfGrass TRENDS website ready soon

TurfGrass TRENDS will soon have a presence on the world-wide-web, at www.landscapegroup.com. The TGT website will contain abstracts of TurfGrass TRENDS articles, with links to other key Green Industry websites and information libraries.

The site, which is currently under construction, will also contain articles and information originally published in *LANDSCAPE MANAGEMENT* and *Athletic Turf Maintenance & Technology*, which, along with TurfGrass TRENDS, make up the Advanstar Communications, Inc. Landscape Group of publications.

Detecting *Rhizoctonia solani* pathogen in turfgrass

Traditional plant disease diagnosis often depends on visual symptoms of necrotic plant tissue, visual signs or evidence of the fungal pathogen and the environmental conditions observed during disease development. This method relies on the principles represented by the "plant disease triangle" in figure 1.

In order for a plant disease to occur, the pathogen must be present and have a viable host to infect and colonize, and the environmental conditions must favor the growth and development of the pathogen over the host. The plant pathologist must rely on "detective-like" skills to

piece the pathogen-host environment information together and properly diagnose the plant disease.

Ideally, the best way to identify *Rhizoctonia solani*, the causal agent of Rhizoctonia blight (formerly called "brown patch") in turfgrasses, is with the aid of a microscope. Through a microscope lens, *R. solani* is differentiated from other turfgrass fungal pathogens by many traits, including characteristic "right angle" branching of the hyphae (Fig. 2). In this decade, advances in molecular biology have led to the identification and development of antibodies that are useful for detecting specific proteins or nucleic acids of plant pathogens. As a result, enzyme-linked immunosorbent assay (ELISA) methods were developed for plant pathogen detection and plant disease diagnosis (1,3,4). Currently, ELISA-based turfgrass disease detection kits are commercially available for identifying *Rhizoctonia solani*, *Sclerotinia homoeocarpa* (causal agent for dollar spot) and *Pythium* spp. (causal agent for Pythium blight). In turfgrasses, diseased or necrotic tissue is sampled and processed in only a few minutes with an ELISA test-kit, then confirmation of the pathogen can be quickly determined. This procedure is fast and easy, and can be conducted on the back of a golf cart, or diseased samples can be taken back to the greenkeeper's office for an ELISA test.

A recent field study conducted in Massachusetts on Rhizoctonia blight showed that the number of fungicide applications could be reduced and acceptable disease control achieved by combining weather-based disease forecasts with ELISA-based confirmation of the pathogen. (5)

In a Maryland study, perennial ryegrass was assayed specifically for *R. solani* (2). In that study, the pathogen detection was influenced by the sampling time-of-day and mowing height. The *R. solani* populations assayed from the leaf tissues were detected

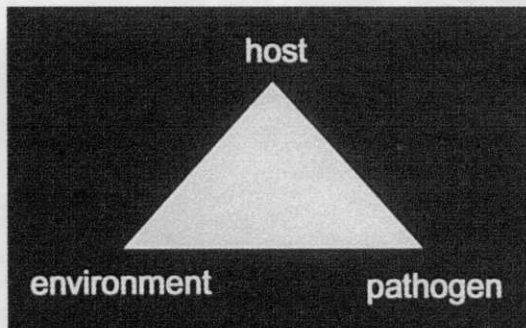


Fig.1 Plant disease triangle represents the plant host/pathogen/environment relationship and its importance in disease development.



Fig.2 Rhizoctonia solani, the causal agent for Rhizoctonia blight, shown under 400x magnification. Notice the "right angle" branching useful in distinguishing this pathogen from others that cause diseases among turfgrasses.

LIST OF FUNGICIDES COMMONLY USED FOR RHIZOCTONIA BLIGHT (FORMERLY CALLED "BROWN PATCH") MANAGEMENT IN TURFGRASSES^{1,2}

Chemical Class	Contact ³ / Penetrant ⁴	Common Name	Trade Name
Benzamide (also referred to as Carboximide)	penetrant ^{4a}	flutaloniol	ProStar
Benzimidazole	penetrant ^{4a}	thiophanate-ethyl thiophanate-methyl	Cleary's 3336 Fungo 50
Dicarboximide	penetrant ^{4b}	iprodione vinclozolin	Chipco 26019 Curalan, Touche
Ergosterol Inhibitors (also referred to as 'DMI' or demethylation inhibitors)	penetrant ^{4c} mycobutanil	propiconazole cyproconazole Eagle	Banner Sentinel
Ethylenebis- dithiocarbamate	contact	mancozeb	Fore, Dithane M-45
Strobilurin (also referred to as Beta-methoxyacrylates)	penetrant ^{4a}	azoxystrobin	Heritage
Substituted Aromatic Hydrocarbon	contact	chlorothalonil quintozene	Daconil, Thalonil PCNB, Terraclor

¹No endorsement of named products is intended, nor is criticism for products that are not mentioned.

²List compiled from the following sources:

- Couch, H.B. 1995. Diseases of turfgrasses, Kreiger Publishing Company, Malabar, FL.
- Vargas, J.M. 1994. Management of turfgrass diseases. CRC Press, Boca Raton, FL
- Watschke, T.L., P.H. Dernoeden, and D.J. Shetlar. 1995. Managing turfgrass pests. CRC Press, Boca Raton, FL.

³Contact: fungicide active on leaf and sheath surfaces.

⁴Penetrant: fungicide is absorbed and can provide activity both on the outside and inside of plant tissues.

(4a – movement in plants is primarily upward)

(4b – limited movement in plants, considered a local penetrant)

(4c – movement in plants is primarily upward, with limited downward movement)

at greater intensity when sampled in the early morning compared to the late afternoon. Also, higher *R. solani* populations assayed from the leaf tissues were detected at greater intensity when sampled in the early morning compared to the late afternoon. Finally, higher *R. solani* population levels were detected from turfgrass mowed at a height of 2.0 inches compared to 0.66 inches.

The ELISA method is a helpful tool that turfgrass managers can use for determining if infected leaf tissue is colonized by the fungal pathogens *R. solani*, *Pythium spp.* or *Sclerotinia homoeocarpa* (2,6). This is particularly helpful in the hot and humid summer months, when diseased turfgrass can exhibit similar symptoms between Rhizoctonia blight (Fig. 3) and Pythium blight, and even dollar spot.



Fig.3 Symptoms of Rhizoctonia blight: necrotic and blighted tall fescue leaf tissue.

Proper diagnosis is critical to turfgrass disease management, especially when considering the use of a fungicide. For example, if a turfgrass manager misidentifies Pythium blight as Rhizoctonia blight, and then applies ProStar (a fungicide specifically targeted to the Basidiomycete fungal group, to which the *Rhizoctonia spp.* belong), the Pythium blight actually infecting the turfgrass will not be controlled.

Also, the fungal mycelium that is observed colonizing the leaf tissue can help in identifying which fungal pathogen is responsible for causing the disease. when environmental conditions are conducive to disease development, the best time to see the mycelium infecting turfgrass is in the early morning hours in the presence of dew or high relative humidity conditions. Even the best plant pathologist will not diagnose the fungal mycelium from a visual observation with the naked eye, but will want to confirm the identity of the fungus under the microscope. For



Fig.4 The actual sign of the fungal pathogen—mycelium of Rhizoctonia solani—colonizing and infecting perennial ryegrass.

example, the color of the mycelium infecting the turfgrass of Rhizoctonia can range from gray to white (Fig. 4) and Pythium and Sclerotinia can range from white to a "cottony-white" appearance. Therefore, testing an infected turfgrass sample with the ELISA method will help confirm which pathogen is causing the disease.

References:

1. Clark, M.F. 1981. Immunosorbent assays in plant pathology. Annual Review of Phytopathology 19:83-106
2. Fidanza, M.A. and P.H. Dernoeden. 1995. Evaluation of an enzyme-linked immunosorbent assay method for predicting brown patch infection in turf. HortScience 30:1263-1265
3. Miller, S.A. and R.R. Martin. 1988. Molecular diagnosis of plant disease. Annual Review of Phytopathology 26:409-432
4. Rittenberg, J.H., F.P. Petersen, G.D. Grothans, and S.A. Miller. 1988. Development of a rapid field-usable immunoassay format for detection and quantification of Pythium, Rhizoctonia, and Sclerotinia spp. in plant tissue. Phytopathology 78:1516
5. Schumann, G.L., B.B. Clarke, L.V. Rowley and L.L. Burpee. 1994 Use of environmental parameters and immunoassays to predict Rhizoctonia blight and schedule fungicide applications on creeping bentgrass. Crop Protection 12:211-218
6. Shane, W.W. 1991. Prospects for early detection of Pythium blight epidemics on turfgrass by antibody-aided monitoring. Plant Disease 75:921-925
7. Zadoks, J.C. and R.D. Schein. 1979. Epidemiology and plant disease management. Oxford Press, N.Y.