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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,

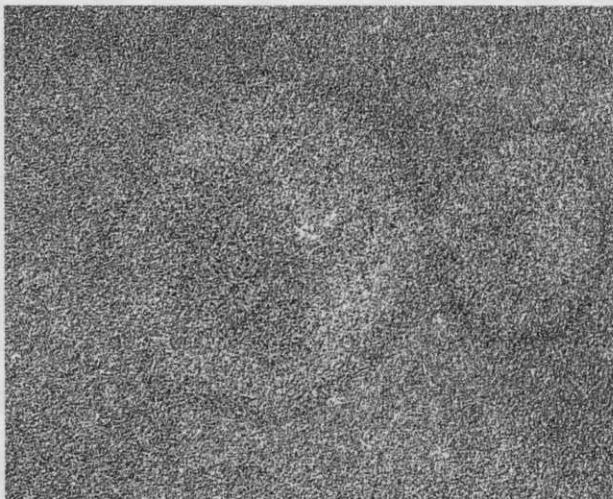


Fig. 2. Note the characteristic "smoke-ring" symptoms of Rhizoctonia blight, commonly observed on closely-mowed putting greens.

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.

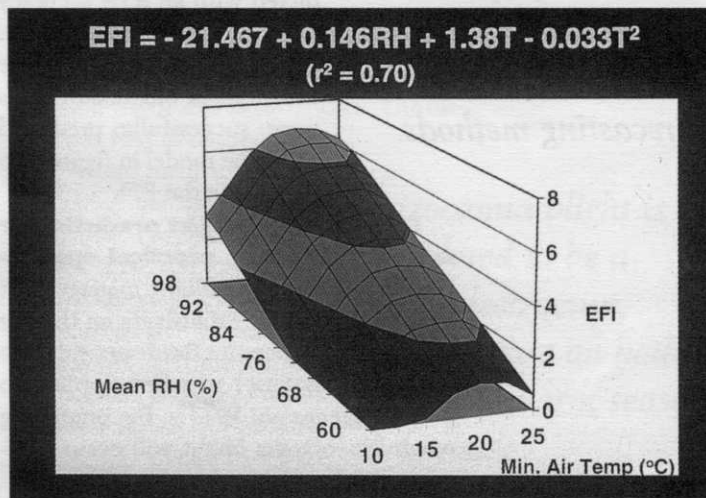


Fig. 4 A three-dimensional representation which depicts how relative humidity and minimum air temperature are related to the development of Rhizoctonia blight in turfgrasses. For example, conditions are favorable for disease development if the mean relative humidity and minimum air temperature combine 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.

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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 conducted by U.S.D.A. scientists in the 1920's and 1930's.

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.

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