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TURFGRASS TRENDS

DISEASE MODELING

What's the Forecast for Turfgrass Disease Modeling?

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Turfgrass managers are under constant pressure to minimize fungicide use, primarily because of economic constraints and environmental concerns. At the same time, customer tolerance for damage from disease is dwindling, and fungicides are becoming more costly and narrow in their control spectrum. Therefore, new tools are needed to support turfgrass managers in their efforts to manage diseases with minimal inputs.

How is it possible to reduce fungicide use in the current environment? Development of a truly integrated disease-management program is essential. Taking advantage of resistant varieties, cultural practices, biological controls and other practices to limit disease development can reduce the number of fungicide applications needed to maintain quality turf. In many cases, however, turfgrass managers are limited in their ability to perform essential disease-management practices such as fertilization, aerification or sand topdressing. Fungicides will always be an essential component of disease-management programs for this reason.

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A fundamental change in the way fungicides are used is also needed in the turfgrass industry. The fungicides coming to the market today are safe and highly effective, but are also expensive and more narrow in their control spectrum compared to the old, contact fungicides. They must be used differently as well because these new products are so different. Accurate diagnosis of turfgrass diseases is becoming more and more important because of this shift in fungicide availability.

In the past, when an unidentified disease occurred, turf managers would often control the disease by trial and error. This "spray-and-pray" approach seemed reasonable at the time, but this is no longer an option because the cost of an unneeded application is too great.

Improving the accuracy of fungicide application timing may also reduce the number of applications needed to maintain high quality turf. Indeed, the fungi that cause turfgrass diseases are highly dependent on certain environmental conditions, such as temperature and moisture, for growth and infection. Therefore, it is theoretically possible to predict disease development based on weather conditions.

Forecasting turfgrass diseases

Most turfgrass managers already attempt to predict disease development based on the weather. When you walk outside on a summer morning and the warm, humid air hits you like a wall, is your first thought, "When's the last time we sprayed for brown patch or *Pythium* blight?" This is your attempt to predict disease development and time fun-

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FIGURE 1

Weather impact?
The activity of a turfgrass disease, such as brown patch, is highly dependent on weather conditions. Can weather data be used to predict disease development and accurately time fungicide applications?

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gicide applications based on weather conditions conducive to the disease.

Plant disease forecasting is a specialty within plant pathology that seeks to predict the development of plant diseases based on weather data. The goal is to improve the timing of fungicide applications and other practices for disease control. This is accomplished by development of a model or statistical relationship between disease development and weather variables.

Models for prediction of disease development can be applied to either observed or forecasted weather data. When observed data are used, the result is a warning model. When forecasted weather data are used, the result is a forecast model. This is similar to the difference between a storm warning and storm watch — a warning model describes the current risk for disease development, whereas a forecast model describes the risk at a specified time in the future.

Most efforts to predict disease development use disease warning models. Forecasting models would be more useful because they allow some lead time for making a preventative fungicide application. However, it is unknown if forecasted weather data are sufficiently accurate for prediction of turfgrass disease development. The confidence and accuracy associated with a weather forecast deteriorates with the forecast lead time. For example, there is higher accuracy and confidence in model estimates of tomorrow's weather as compared to next week's weather.

A variety of weather-based models have been developed for prediction of turf disease development. These models vary in their complexity as well as the disease they aim to predict. For example, models are available for all of the most important turfgrass diseases — brown patch, dollar spot, *Pythium* blight, gray leaf spot, anthracnose, summer patch and take-all patch. Yet few turfgrass managers use these models to assist in timing of fungicide applications.

There have been two main limitations to the widespread use of disease forecasting by turfgrass managers. First, it is believed that site-specific weather data are needed to accurately predict disease development, but this type of data is expensive to collect and not always readily available. Second, there has been no systematic, dedicated effort to develop disease prediction models that are accurate on a regional scale.

The North Carolina project

At North Carolina State, we have initiated a project to develop a system for prediction of turfgrass-disease development based on weather conditions. A diverse team comprised of turf scientists, agrometeorologists, weather forecasters, computer programmers and geographic information systems (GIS) specialists has been assembled to accomplish this goal.

In 2003, two turf disease warning models were evaluated in the field for their ability to predict brown patch development in creeping bentgrass. The Schumann Model was developed from observations on creeping bentgrass in Massachusetts, and the Fidanza Model was developed in Maryland from observations on perennial ryegrass.

The Schumann and Fidanza models both use temperature and moisture thresholds to predict development of brown patch, but these models differ in how the thresholds are implemented. The Schumann Model has a list of criteria that must be met for brown patch to develop. The Fidanza Model uses a mathematical formula to calculate a value, called E2, which indicates the degree of risk for brown patch development. E2 values greater than or equal to six indicate the potential for brown patch activity.

One advantage of a threshold based model is that turfgrass managers can modify the E2 threshold based on their management practices or microclimates. For example, a threshold of four may be more appropriate for a putting

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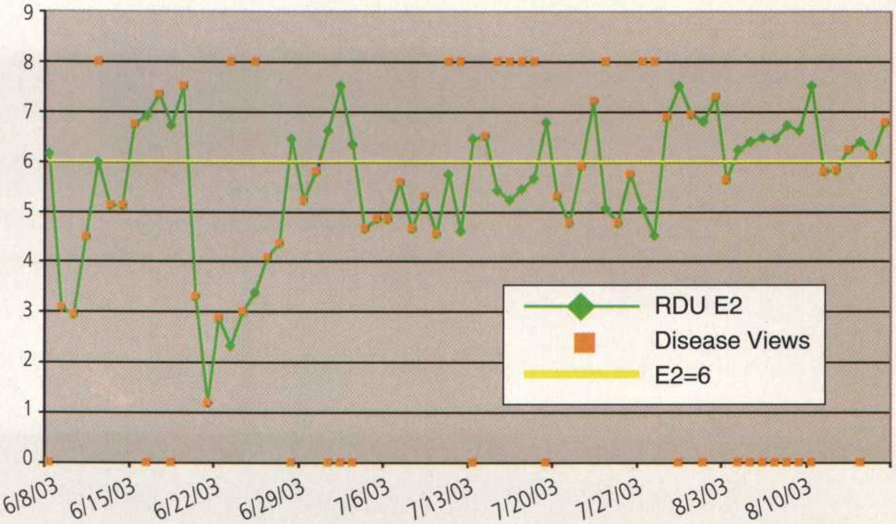
FIGURE 2

Fidanza Model E2 values generated from Raleigh Durham airport (RDU) weather data compared to daily observations of brown patch development. E2 correctly predicted whether or not brown patch would develop on days when disease observations (pink squares) lie on the E2 curve. E2 issued false alarms on days when disease observations = 0. E2 missed brown patch activity on days where disease observations = 8. The E2=6 line indicates the threshold for brown patch development according to the Fidanza Model.



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green with poor soil drainage or that is surrounded by trees.

To test the two models, monitoring of brown patch activity was conducted on creeping bentgrass at the Faculty Club Turfgrass Field Lab in Raleigh, N.C., in 2003. The plot was established with individual 1,250 square-foot blocks of the cultivars SR1119, G-6, G-2, Crenshaw, L-93, Penncross, A-4 and A-1 maintained under putting green conditions.

North Carolina State University seeks to develop a system for prediction of turfgrass disease development.

Visual observations of disease development were conducted on a daily basis from June 2, 2003, through Aug. 17, 2003. Brown patch development was detected by the presence of a smoke ring surrounding the infection centers. Weather data was collected from the National Weather Service site at the Raleigh-Durham International Airport, which is about 11 miles from the field research site.

Brown patch pressure was relatively low in North Carolina in 2003 because of unusually cool weather conditions. At our study site, brown patch activity was observed on 23 of the 70 days from June to August. The Schumann Model correctly predicted only five of the 23 brown patch outbreaks. The Fidanza Model was slightly better, correctly predicting 11 of the 23 brown patch outbreaks (Figure 1). Thus both the models failed to be sufficiently accurate to use in timing of fungicide applications.

Although the Fidanza Model is not sufficiently accurate for immediate use in North Carolina, this model may serve as a starting point for development of a new model. During analysis of the results, two common themes were noted on days when the Fidanza Model was incorrect. First, high temperatures (86 degrees Fahrenheit or greater) were noted on the day preceding 11 of the 12 days when this model missed brown patch development. Second, precipitation exceeding .1 inch occurred overnight on 13 of the 18 days when the Fidanza Model issued a false alarm.

A modified Fidanza model that accounts for high temperatures and timing of rainfall may prove to be more accurate for prediction of brown patch development in North Carolina.

As mentioned above, there is a perception that on-site weather data are needed to accurately predict disease development. This has been a major limitation to the use of disease forecasting. Many golf courses are equipped with weather stations, but it's difficult to access this data for use in disease forecasting. Weather stations are also cost-prohibitive for many turfgrass managers, and require regular calibration and maintenance. There are many other sources of weather data available — collected at airports and DOT weather stations.

Can these weather data be used to predict disease development in the turfgrass environment?

To answer this question, three sources of off-site weather data were collected and analyzed in 2003.

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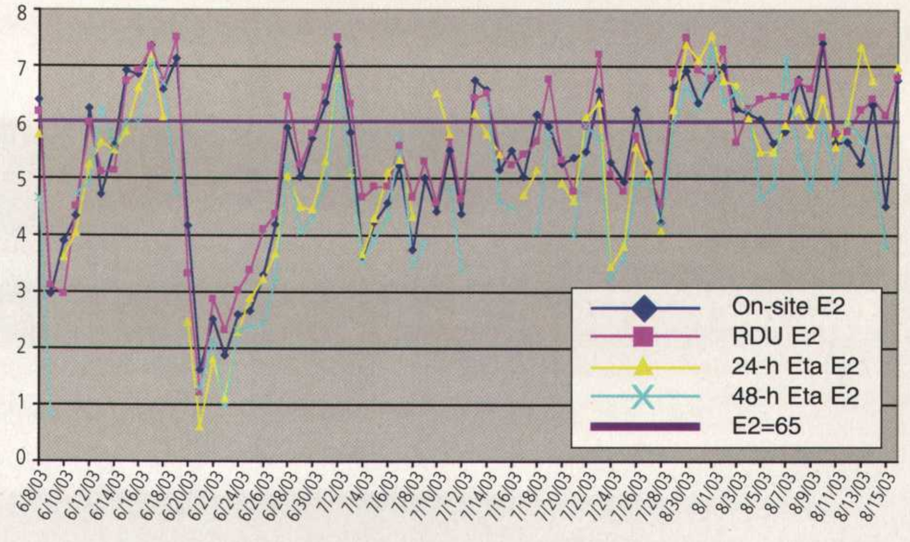
FIGURE 3

E2 values derived from meteorological data collected on-site, from Raleigh Durham (RDU) airport, and 24-hour and 48-hour forecasts according to the Eta weather model. The E2=6 line indicates the threshold for brown patch development according to the Fidanza Model. 24-h Eta forecasts were not available on June 9 and 19; July 9, 12,16 and and 19; and Aug. 15. 48-hour Eta forecasts were not available on June 10 and 20, July 10, 13, 17, and 20, and Aug.16.



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On-site weather data was collected by a Campbell Scientific weather station situated directly on the research green. Forecasted weather data (24-hour and 48-hour forecasts) were compiled from the National Weather Service Eta model. The E2 value was calculated from these three sources of weather data and compared to the E2 values from airport weather data discussed above.

The airport and on-site weather data differed in their prediction of disease development on nine days during 2003 (Figure 2). On-site data correctly predicted whether or not brown patch activity was observed on five of the nine days, whereas the airport data correctly predicted disease development on the remaining four days. Therefore, the use of on-site weather data improved the accuracy of disease forecasts by only one out of 70 days. This slight improvement in accuracy probably does not justify the expense of purchasing and maintaining an on-site weather station, although additional research will be needed to complete a cost-benefit analysis.

In general, forecasted weather data tended to underpredict the E2 value when compared to airport weather data (Figure 2). There was, however, a relatively consistent relationship between observed and forecasted E2 values. As expected, 24-hour forecasts appeared to be significantly more accurate than 48-hour forecasts. Forecasts longer than 48 hours are not likely to be sufficiently accurate for prediction of turfgrass disease development.

The future of turfgrass disease prediction

By optimizing the timing of fungicide applications, disease forecasting has the potential to reduce the number of applications needed to maintain high-quality turf.

However, there is much work to be done before this technology can be used by turfgrass managers. Our research indicates that off-site weather data, collected from airport weather stations or other sources, can be used to predict disease development nearly as accurately as data from on-site weather stations. This result has major implications to our efforts to develop an Internet-based system for disease forecasting.

By using off-site weather data, it will be possible to produce disease outlooks for turfgrass managers, whether or not they have an on-site weather station. There also appears to be potential in the use of forecasted weather data to predict disease development up to 48 hours into the future. At this point, the primary limitation to the use of disease forecasting is the accuracy of the disease prediction models themselves, rather than the meteorological data. Continued research is needed to develop models that are accurate on a regional scale. ■

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