DISEASE PREDICTION FOR GOLF COURSES

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INTRODUCTION

Turf managers are under considerable pressure to justify and, preferably, reduce their pesticide applications. At this time, most fungicide applications involve educated guessing. Unlike weed and insect pests which can be counted, turf managers must use past experience and weather predictions to determine when diseases are likely to occur. Disease prediction systems offer a way to make more precise and timely applications that may improve disease control and perhaps even reduce the number of applications.

Fungicide applications may be reduced in two ways. First, conducive weather conditions may approach but not quite reach the levels necessary for a disease outbreak. If a turf manager is able to monitor these conditions more precisely, fungicide applications may be safely skipped when they are not needed. Second, many biocontrol agents are currently being studied. Because they are living organisms, there is a concern that they might have limited use if they are active for only a short time. If they could be applied when disease pressure is greatest, their short-term activity might be very effective and reduce the need for fungicide applications.

There are two main approaches to disease predictions. Disease prediction may be made by monitoring environmental conditions that lead to disease outbreaks. Predictions may also be made to monitoring the activity of the pathogen that causes the disease through the use of immunoassays, or antibody tests, such as the commercial Reveal® field diagnostic kits.

DISEASE PREDICTION BY ENVIRONMENTAL MONITORING.

The initial step in the study of any turf disease is to determine what environmental factors lead to disease development. It is well known that fungi that cause turf diseases are active over a wide range of temperatures. Even though some are more active at high temperatures and others at lower temperatures, there is still considerable overlap in the temperature range of activity. Temperature alone is not enough to predict most turf diseases.

The most important additional factor is water. This may be soil moisture, high relative humidity, actual water droplets on leaf blades, or some combination of these factors. In general, there are particular combinations of moisture and temperature that allow a fungus to invade a turfgrass plant. These combinations of appropriate environmental factors are called "infection periods." Infection periods can be used to predict disease outbreaks.

Two commercial computerized environmental monitoring stations are currently available to turf managers, the Envirocaster and the Metos Golf. Both of these instruments monitor environmental factors several times each hour and store all of the hourly environmental data. Computer models that calculate turf disease predictions from these data and can be accessed at any time. The use of computerized environmental monitors allows the models to reflect the biological complexities of the real world without overburdening a busy turf manager with time-consuming calculations.

For severe diseases such as Pythium blight and brown patch (Rhizoctonia blight), turf managers should be informed each time an infection period occurs. When environmental conditions are not favorable for disease, the message from the computer may simply state that an infection period has not occurred. Infection period models may determine if a disease outbreak is likely to be severe, moderate, or light which may be helpful in making a fungicide application decision. Disease prediction systems may also include recommended cultural practices such as avoiding mowing or irrigation during a time when the risk of spreading active fungal mycelium is high. The computer may also list the current limiting factors as conditions approach those needed for an infection period. For instance, if the daily maximum temperature is the limiting factor for an infection period and the day is definitely going to become hotter, then an infection period will probably occur. Thus, environmental monitoring can be combined with current weather predictions to predict disease outbreaks.

Infection period models are most useful for diseases that develop quickly and can be very damaging. Other turf diseases are more a matter of degree. Fungicide applications are usually made after disease potential reaches a certain level of severity. Severity prediction models are more useful for these diseases which include anthracnose, leaf spot, and red thread. Such a model has been created for anthracnose at Michigan State University. It accumulates "anthracnose severity units" based on leaf wetness and average air temperature. While it is actually based on infection periods, it predicts disease after a series of infection periods each of which accumulates points according to the Anthracnose Severity Index. A fungicide application is made only when a certain threshold number is reached. Severity prediction models have the added advantage allowing a turf manager to modify the threshold number to meet the specific needs of a particular golf course.

A third type of prediction model has been applied to other pest problems, but has few applications for turf diseases at this time. It is based on the concept of "degree days" which reflect an accumulation of "heat units" during a growing season. Degree days are a way to measure what we intuitively sense when we notice that a year has an "early spring" or a "late spring." This concept has been applied to certain pest control measures that are timed according to the blooming of forsythia or other plant development stages. The development of all organisms is tied to the accumulation of degree day units. By doing experimental work on a specific pest, it is possible to accurately determine the degree day thresholds for that pest. As with the disease prediction models already described, however, degree day models are monitoring only the environmental conditions, not whether there is enough of a pathogen to warrant control.

A degree day prediction model exists for *Poa annua* seed head formation. Degree day models have also been determined for several important turf insect pests including Japanese beetle and annual bluegrass weevil. Degree day models have important potential applications for disease prediction as well. For instance, it is known that brown patch is a summer disease. Even though hot, humid weather may occur briefly in spring, it does not seem to trigger brown patch until soil temperatures reach a critical threshold. Because soil temperatures can vary considerably from week to week, a degree day threshold might be the most appropriate way to determine when in early summer to start using a daily brown patch infection period prediction system.

Summer patch and necrotic ring spot are difficult diseases to manage because fungicide applications must be applied preventively before symptoms occur. A degree day model might be an accurate means of determining when fungicide applications should be applied to be most effective.

IMMUNOASSAYS FOR PATHOGEN DETECTION

All of the prediction methods just described are based solely on environmental monitoring. They determine that conditions are right for disease development. They are unable to determine if a previous fungicide application is still actively suppressing disease or if the fungus population is sufficient to cause significant disease. Another newly developing technology may provide this missing critical information.

Tests are available for rapid and quantitative detection of pathogens in turfgrass. They are called immunoassays or antibody tests because they are derived from antibodies formed by the immune systems of animals.

Highly purified samples of turf disease fungi can be injected into animals. The animals do not become diseased, but their immune systems still recognize these fungal proteins as "foreign." Antibodies specific to each fungus are formed. The antibody-producing cells can be grown in culture for inexpensive mass production of antibodies. Field kits containing the antibodies combined with a special enzyme have been created which require no specialized equipment or training and indicate the presence of the fungus by a color change. At this time, kits are available for detection of the fungi that cause brown patch, dollar spot, and Pythium blight. Each test is developed with antibodies specific to only one pathogen. Thus, a separate test must be run for each disease.

The next question is whether a threshold fungus population requiring treatment is present. A meter is available that measures the intensity of the color development in the test. A darker color will result in a higher number which reflects a greater amount of fungus detected in the sample. It is important to sample turf in areas where disease is expected to develop first, areas sometimes known as "hot spots." It is also important to avoid including thatch and soil in the test because pathogens are almost always present in thatch and soil.

PREDICTING BROWN PATCH WITH ENVIRONMENTAL AND IMMUNOASSAY MONITORING

At the University of Massachusetts, we have developed a preliminary infection period model for brown patch on creeping bentgrass maintained as a putting green. We found that soil temperature (minimum and average), air temperature (minimum and average), high relative humidity duration, and rainfall/irrigation episodes were key factors in disease outbreaks. After determining the thresholds for each of these factors, we tested our preliminary environmental model and the immunoassay monitoring system in two other regions with the cooperation of Dr. Bruce Clarke at Rutgers University and Dr. Lee Burpee at the University of Georgia for two summers.

We recorded the number of fungicide applications, the total amount of disease that occurred over the entire seasons, and the number of individual days in which disease exceeded current commercial expectations of control (<5%). In the second summer, we also tested a combination of the environmental prediction system with the immunoassay system. We applied fungicides to the immunoassay test plots only when an environmental prediction was confirmed by an immunoassay result above our experimental threshold of 23 on the meter.

We found that the environmental prediction system was relatively conservative and did not miss predicting any major disease outbreaks in any of the three regions in either summer. Both the environmental and immunoassay systems were able to reduce fungicide applications. One of the disadvantages of the immunoassay system is the variability of results from samples in the absence of disease symptoms. In our experiments, four tests were run each time to sample each of the four replicate plots, and a fungicide application was made if any one of the four results exceeded the experimental threshold of 23. If several tests are required to accurately determine fungal activity, the time required to run the tests and the expense of this system might be impractical. The environmental prediction system overpredicted on numerous occasions in the hotter conditions of Georgia and should probably be modified for use in that region. Overprediction also occurred in New Jersey and Massachusetts, but nearly all of the false predictions could be eliminated by observing weather prediction for the 48 hour period following a prediction. If the minimum air temperature will fall below 59°F, the prediction should be cancelled. The use of this prediction cancellation should result in an even greater reduction in fungicide applications for brown patch without risking disease injury.

CONCLUSIONS

One of the limitations to the use of disease prediction systems on golf courses is that fungicide applications must be made fairly soon after a prediction occurs. This may not seem practical for some turf managers at this time. However, future pesticide regulations may require greater justification for fungicide applications, and prediction systems offer a scientific basis for your records. Further research is necessary to make the current prediction models more accurate and for the development of models for additional diseases. Disease severity is affected by many factors in addition to environmental ones. These include differences in cultivar susceptibility and pathogen races in various geographical areas. Other important factors that affect disease severity are nutrient levels, use of plant growth regulators, mowing height, and various soil factors. Predictive models will become fine-tuned over time to become more accurate, but they must always be carefully evaluated before use in new areas to make sure that the predictions are appropriate for the local conditions.

Disease prediction by environmental monitoring and immunoassays will probably be a part of every fungicide application decision in the future. As these technologies improve, turf managers should be able to get better control through more precise timing of applications and also have the confidence to extend spray intervals when conditions are not conducive for disease. Immunoassays that can measure fungicide residues may be developed in the future and would be an invaluable tool in applications decisions. Environmental and immunoassays prediction systems are an easy and accurate way to document and justify when fungicide and biocontrol applications are necessary.