Report to the
United States Golf Association

On the project:
A Disease Management Program to Reduce Pesticide Use on Bentgrass Greens

By
Jack Bailey and Jason Latta
Department of Plant Pathology
North Carolina State University

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Executive Summary

Weather-based advisory models, which key fungicide application during periods of favorable conditions, have not been widely used on golf courses due to the lack of evidence that they are accurate. Turf managers often rely upon calendar-based spray schedules. An ideal fungicide application program would consider all environmental factors associated with disease activity, and treatments would be made only when conditions were most favorable for disease outbreak. Therefore, determining specific environmental conditions most critical for disease outbreak, and improving cultural practices and environmental conditions prior to these outbreaks, could aid in reducing the number of chemical applications. The use of electric fans among turf managers has grown rapidly for use around 'pocket greens' which has been observed to increase turf quality. The objectives of this study were to: a) determine how wind velocities affect the turf microclimate, turf quality, and brown patch incidence, and, b) verify the relationship between weather-based advisories and disease progress. In our studies, brown patch was dramatically reduced in the areas of greatest wind velocity. Where the fans were left on and irrigation was inadequate, dollar spot was more sever. Soil moisture, algae, leaf wetness, and canopy temperatures were all less in the area of greatest wind velocity. Turf quality was highest in the same area. A regression equation was generated to define the relationship between wind velocity and brown patch (disease incidence = 0.816608 – 0.314186 * wind velocity (m/s)). This equation describes the effect wind has on decreasing the incidence of brown patch. A weather-based model (Fidanza model) will be modified with this equation to determine if this will correct some of the problems it has in predicting disease. In the 2000 growing season several versions of the "wind modified" Fidanza model will be tested to see if they can be used to accurately predict the need for fungicide applications. Several commercially available fans will be characterized to determine the wind movement profile so that the appropriate selection and placement of these fans can be made to complement the natural airflow over greens. A radio controlled aircraft will be used to document the geometric effects of wind flow over greens to verify the accuracy of these predictions. It is anticipated that this project will reduce the use of fungicides on golf course greens by changing the microclimate to be less conducive to disease. This should help golf courses fall into compliance with the new FQPA standards.

Introduction

Rhizoctonia solani is a soil-inhabiting fungal pathogen that incites brown patch (Rhizoctonia blight), a foliar disease which attacks both warm- and cool-season turfgrasses. In cool-season grasses, disease onset favors warm, moist, and humid environmental conditions, while onset is apparent in warm-season grasses either right before or as grasses break dormancy during cool, moist conditions. Brown patch is severe on creeping bentgrass maintained under golf course putting green conditions, which include; close mowing, high fertilization rates, and frequent watering. Despite the use of cultural practices to manage the disease, frequent fungicide applications continue to be relied upon for disease control.

Weather-based advisory models, which key fungicide application during periods of favorable conditions, have not been widely used on golf courses due to the lack of; compelling evidence that they are accurate, and unreliable complex, and expensive weather equipment. Therefore, turf managers have traditionally relied upon calendar-based spray schedules. Fungicides used for brown patch control, are typically applied from June through August at intervals ranging from 5 to 21 days. Excess chemical usage is commonly associated with such calendar-based schedules as disease development is typically intermittent throughout the growing season. An ideal fungicide application program would consider all environmental factors associated with disease activity, and treatments would be made only when conditions were most favorable for disease outbreak. Therefore, determining specific environmental conditions most critical for disease outbreak, and improving cultural practices and environmental conditions prior to these outbreaks, could aid in reducing the number of chemical applications.

Weather-based advisory models have been developed and used on numerous crops, however, just recently have they become an important topic in the turf industry. Numerous researchers have addressed this issue. One of the more recent efforts was that of Fidanza et al. They concluded that brown patch could be predicted using the temperature and relative humidity. Lyford, Bailey, and Peacock showed that this model was correlated to disease out breaks at low wind speeds but became less predictive as the wind speed increased to 3 m/s, where little or no disease occurred.

The use of electric fans among turf managers has grown rapidly for use around 'pocket greens' which has been observed to increase turf quality. Proponents for the use of fans claim they aid in decreasing disease incidence, foster drying of wet greens, and increase the survivability of the turf. Early attempts to define the relationship between environmental parameters and disease occurrence were reported by Duff and Beard (1966), who showed a correlation of air movement on the microclimate of bentgrass turf. Duff and Beard determined wind velocities of 1.7 $m\ s^{-1}$ had a significant temperature difference at the turf canopy and at a depth of 5 cm below the turf canopy compared to zero wind control. Grace and Russell (1977) studied the effects of wind on tall fescue and the influence of continuous wind and drought on plant anatomy and water relations.

Grace (1974) studied the effects of transpiration of tall fescue at two different wind speeds in a controlled-environment wind tunnel. The experiment was conducted with wind treatments of 1 m/s. Transpiration rates varied from day to night, 11 mg $H_2O\ cm^{-2}\ h^{-1}$ to 0.7 mg $H_2O\ cm^{-2}\ h^{-1}$ respectively. Leaf water content ranged between 94 and 98%, highest at nighttime. Grace observed that an increase in airflow, from 1.0 m/s to 3.5 m/s, increased the transpiration rate of the leaf blades, decreased leaf water content and leaf exudate at the leaf tip. Daytime transpiration rate increased and diffusive resistance decreased by 30% when wind velocities were increased from 1.0 to 3.5 m/s.

More recently, Taylor (1996) reported fans reduced leaf water potential, leaf osmotic potential, and leaf turgor potential on creeping bentgrass. Taylor reported an increase in wind velocity from 1.4 to 2.6 $m\ s^{-1}$ decreased soil temperature at 5 cm, and decreased surface and canopy temperatures during periods of peak net irradiance. A decrease in soil moisture percentage was also reported. Taylor reported wind velocities in excess of 2.6 m/s may result in detrimental reductions in soil moisture and leaf water potential. Taylor concluded wind velocities in the 1.8 $m\ s^{-1}$ range seemed most beneficial for a healthy stand of turf. Although temperatures, leaf water potential, and soil moisture were reduced, levels were not detrimental to the turf's health.

Due to the extensive variability of the pathogen and the environment, initial disease development may vary considerably from day to day. However, turf managers rarely change their calendar sprays accordingly. Managers will apply fungicides despite the fact environmental conditions are not favorable for an outbreak. Excessive fungicide use can be high. However, it may be possible to reduce fungicide use by altering these conditions which lead to disease outbreaks, or by predicting disease outbreaks before they occur, and spraying only when needed.

The following is work completed in the last year by Paul Lyford (now graduated) and Jasson Latta (beginning second year of MS program).

Objectives: a) determine how wind velocities affect the turf microclimate, turf quality, and brown patch incidence, and, b) verify the relationship between weather-based advisories and disease progress.

Materials and Methods

Two fully mature 'Crenshaw' creeping bentgrass golf greens at the Sandhills Research Station, Jackson Springs, NC, and the Country Club of North Carolina, Pinehurst, NC were selected for the experiment. One green was constructed on a native Arenic Paleudult, Sandy, Siliceous, Thermic (Candor sandy) soil. The second green was constructed on a native sandy soil. Turf was clipped at a height of 5 mm, to simulate normal daily maintenance operations for a golf green. Irrigation was applied as needed to prevent wilt. A 10.9 x 14.6 m section from each green received supplemental wind from three 372 watt, 35.5 cm diameter fans (Patterson Fan Co., Greenville SC) positioned 1.8 m apart, and 1 m above the turf canopy. To alleviate off center output to the left or right of the fans, a set of three louvers were installed on the front of each fan. During periods of little ambient wind fans provided average air velocities ranged from 0.3 m s $^{-1}$ to 2.7 m s^{-1} (measured at 3 cm above canopy) across the turf canopy. Six distances from the fans were selected as data collection points providing average velocity treatments above ambient air of 2.7, 1.6, 0.7, and 0.3 m s $^{-1}$, two of the distances, 11.25 m and 13.68 m, received no artificial air movement from the fans. Six replications were located on the greens, one located in front of each of the three fans (i.e. three artificial wind reps), and three located without any additional airflow from the fans.

Each of the 36 plots, 19.68 x 26.24 m, were permanently marked before the start of the experiment. Fans ran continuously for the duration of the experiment in all three years (1997, 1998, and 1999).

Environmental Monitoring

In addition to the continuously monitoring weather stations, other measurements were recorded on a less frequent basis (1997/1998). Air and soil temperature, dew point, and relative humidity were measured via two weather stations (Agricultural and Meteorological Systems, Inc., Middlesex, North Carolina) (1997-1999). Stations ran throughout the study collecting data every fifteen minutes, while displaying results on a personal computer. A soil temperature probe connected to the weather station was buried 30.48 cm from the sensor housing, at a horizontal position, 5.08 cm below the turf canopy. Wind speeds were obtained using a Alnor 8500 thermo-anamometer (The Penn Company., Charlotte, North Carolina) placed 3 cm and 1 m above the canopy. Turf canopy temperatures were measured three times a week using an infrared temperature transducer (Omegascope Engineering Inc., Stanford, Connecticut) gathering information on a rectangular turf area 19.68 x 26.24 m. The infrared transducer was held 1 m above the canopy and set at a 40 ° angle to the turf surface.

Two weather stations (Agricultural and Meteorological Systems Inc., Middlesex, North Carolina) were located at each site placed 4.2 m and 11.5 m from the base of one van, 6 cm above the turf canopy. Every fifteen minutes the stations monitored air and soil temperatures, dew point, and relative humidity. The stations collected data throughout the study.

Wind speeds were monitored twice a month, during the morning hours. A total of 128 collection days were made during both the1997 and 1998 seasons. During both the 1997 and 1998 studies, measurements were made every other day, three times a week, or when weather permitted.

Soil moisture percentage was determined using a time domain reflectrometer (TDR) (Soil Moisture Corporation, Goleta CA) fitted with 15 cm wave guides. Soil moisture percentage was recorded for each plot twice a week. Data was entered into a personal computer for storage and future calculation of soil moisture percentage. Duration of leaf wetness was monitor once a month for three months throughout the evening hours during both 1997 and 1998 studies. Water sensitive paper, 2.54 x 7.62 cm, (Spraying Systems Co., Wheaton, IL) were placed on each plot, applied with light pressure, to monitor dew formation and evaporation associated with varying wind velocities. The percentage of the paper affected by the water, indicated by a yellow to blue color change, was recorded and entered into a personal computer. Measurements were taken every hour on the hour from 8:00 pm, ending 11:00 am.

Disease and Turf Quality Evaluations

Observations made (1997-1999) included visual tri-weekly readings of brown patch occurrence (1997-1999) and turf quality (1997-1998). Brown patch was monitored and recorded for each plot on a scale of 0 - 100%; 0 % representing no visible brown patches and 100 % representing the entire plot covered with brown patch. Turf quality was a function of its utility, appearance, and playability during the season. Quality was rated on a 1 to 9 scale with 9 representing the most favorable for golf course green conditions. Visible determinants of quality included density, texture, uniformity, color, growth habit, and smoothness.

Results

Results from these studies can be seen in the figures at the end of this text. Only one set of figures is presented to represent two or three years of data collection as the results were very consistent.

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Plans for 2000

Create method of determining number, type, and operating schedule needed for optimal fan usage needed for greens of varying dimensions

The geometry, dimensions, and topography of greens affect the types and numbers of fans needed to generate homogenous and adequate wind speeds to have the desired disease mitigating effects. The ambient environment dictates the need for fans to be running. Each fan type has a three dimensional pattern of air movement. These factors will be incorporated into an algorithm to determine the type; height, array, and angle of placement to achieve the desired drying.

Modification and testing of the Fidanza model

A regression equation describing the effect of wind speed on disease incidence will be used to modify the Fidanza model. Several new versions will be tested in fungicide trials in the summer of 2000.

Characterization of commercially available fans

The air flow from three commercially available fans (Patterson, the Tempest, and the Whisper Breeze) used on golf courses will be characterized by measuring wind speeds at various heights and widths. The experiment will be conducted in a warehouse to minimize the influence of ambient air. The profiles will be used in the construction of an algorithm to determine fan placement (height, angle, and air movement capacity) on greens to maximize uniformity and positive effects of artificial air movement on bentgrass greens of various shapes, sizes, and topography.

Assessment techniques

Disease assessments will be made on the ground by estimating the percent of turf affected. Another technique will use remotely piloted vehicle (RPV). An remote controlled aircraft was built with a radio controlled camera to take images from one to several hundred feet in the air. This information will be digitized and used to verify the accuracy of the fan profiles as defined in the warehouse study.

Geographically accurate image analysis requires that data be recorded directly above the site to be analyzed. To achieve this, An RPV has been designed at the Aerospace Engineering Department at North Carolina State University. This RPV operates on the premise of a glider. An Olympic Stylus 35 mm camera has been purchased to be mounted inside the belly of the aircraft to provide aerial imagery using infrared film of disease progress and the effects of the fan on disease and dew formationImages of disease and dew formation will be used to determine the area of influence of fans as calculated by the fan placement algorithm.

Impact

It is anticipated that this project will reduce the use of fungicides on golf course greens by changing the microclimate to be less conducive to disease. This should help golf courses fall into compliance with the new FQPA standards.