Disease Forecasting System for Warm Weather Pythium Blight of Turfgrass

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ABSTRACT

Nutter, F. W., Cole, H., Jr., and Schein, R. D. 1983. Disease forecasting system for warm weather Pythium blight of turfgrass. Plant Disease 67:1126-1128.

A forecasting program based on weather monitoring was developed to help turfgrass managers predict warm weather Pythium blight. Two weather variables were associated by chi-square analysis with Pythium outbreaks during the 1978, 1979, and 1980 growing seasons: 1) a maximum daily temperature higher than 30 C, 2) followed by at least 14 hr of relative humidity greater than 90%, provided the minimum temperature was higher than 20 C. A forecasting day ran from noon to noon. When fungicides were applied soon after these criteria were met, significant Pythium blight damage was prevented. In contrast, in areas where fungicide treatments were not applied, Pythium blight infection and damage usually occurred.

Turfgrass is a perennial vegetative cover that is not harvested seasonally, a situation that favors introduction and long-term buildup of pathogenic organisms. *Pythium* and other important pathogens are usually present and require only favorable environmental conditions to become active enough to cause damaging levels of disease (1–6). Warm weather Pythium blight, caused primarily by *Pythium aphanidermatum* (Edson) Fitz, may occur infrequently during the season, but the fungus spreads rapidly and can cause extensive damage if temperature and moisture are favorable (1). If the turf is mostly bentgrass (*Agrostis palustris*), large areas may be killed, requiring extensive stand renovation. *P. ultimum* may also cause turfgrass disease (1).

Turfgrass managers must consider savings from not applying preventive fungicides on a regular basis against the cost of renovating blighted areas if a serious outbreak should occur. Calculated savings from not spraying can be very large, but renovation may also be costly if serious disease occurs. In a 1979 survey (P. L. Sanders and F. W. Nutter, *unpublished*) of Pennsylvania golf course superintendents, 5% applied preventive *Pythium*-specific fungicides regularly to fairways and 35% applied them to greens and tees. These figures probably reflect the managers' informal cost-benefit judgment.

Bentgrass plants grown at an average temperature of 30 C (85 F) were most seriously damaged by *P. ultimum* (5). The optimum temperature for disease development for *P. aphanidermatum* is near 35 C (2). Below 20 C, damage from *P. aphanidermatum* is negligible and damage caused by *P. myriotylum* drops off sharply at temperatures below 30 C (3).

Both *P. ultimum* and *P. aphanidermatum* were reported most aggressive at air temperatures of 30–35 C, whereas below 20 C, no visible evidence of infection was detected (1). It has been postulated that a temperature cycle of 20 C at night and 36 C during the day is most conducive for warm weather Pythium blight (6).

The most comprehensive work regarding the relationship between weather and Pythium blight is that of Hall (4), who investigated field occurrence vs. weather variables by multiple regression analysis and correlation analysis techniques. Hall concluded that an average temperature above 20 C for at least 10 hr was needed before blight occurred but that no other obvious correlation could be made between severity of Pythium blight and weather conditions. In light of this previous work, experiments were initiated to determine if warm weather Pythium blight could be predicted by selected temperature and relative humidity criteria.

MATERIALS AND METHODS

In 1978, three golf courses were selected for weather and disease monitoring. All three courses contained creeping bentgrass fairways. All test locations were fairway sites essentially free of annual bluegrass (*Poa annua*). The Pittsburgh course varied little in topography and Pythium blight was perceived to have a high disease potential in all locations. The Verona course was also limited in topographic variation but, in general, was perceived to present a low to moderate disease risk, depending on location. The Gladwynne course varied greatly in topography and was thought to have very low to very high *Pythium* risk, depending on the specific location.

Hygrothermographs (Model H311, Weather Measure Corp., Sacramento, CA 95841) were placed in three areas within the golf courses where Pythium blight had occurred most often in previous seasons, in areas where disease had occurred in some years, and in areas where blight had rarely occurred. Each hygrothermograph was housed in a standard white shelter about 15 cm above the soil line. Weather data were recorded from 8 June to 15 September; thus, 100 days of data were collected for three locations on each of three golf courses. Hygrothermograph records were used as the basis for computing minimum, maximum, and mean daily temperatures, the number of hours relative humidity (RH) was greater than 90%, and the mean temperature and the number of hours that temperatures were higher than 20 C during this high-humidity period. Rain gauges recorded precipitation and irrigation to the nearest millimeter. A forecasting day ran from noon to noon, a period that usually included the maximum temperature, the nighttime high humidity, and the minimum temperature.

Pythium blight was monitored daily by course superintendents. Disease was determined visually by the presence of cottony mycelium in association with water-soaked, blighted foliage. No attempt was made to evaluate disease severity. In all instances, *P. aphanidermatum* was the pathogen, confirmed by periodic isolations from diseased foliage. Only new outbreaks or renewed activity on previously diseased areas were recorded. Although residual symptoms might have been present after an outbreak, these were not recorded as disease occurrence unless new activity or spread took place. Thus, for each forecasting day, only two possible classes of Pythium blight were recorded: blight occurred (+) or did not occur (−). Weather data were subjected to analysis of variance (ANOVA) and Duncan's modified least significant difference test (DMLSDT).

In 1979, the study was expanded to include one additional golf course located at Newtown Square, PA. Three creeping bentgrass fairway sites were monitored within each golf course for about 100 days. In this manner, 300 forecasting days were obtained per golf course in 1979.

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Accepted for publication 18 April 1983.

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Chi-square analysis of 2 × 2 contingency tables was employed to test the null hypothesis that there was no relationship between weather variables and Pythium blight occurrence.

In 1980, a test was made of the forecasting system developed from 1978–1979 data. A single hygrothermograph was located in the site most prone to Pythium blight on each of three golf courses (Pittsburgh, Verona, and Bethlehem). Each superintendent made his own forecast. When the need for a fungicide treatment was indicated, chloroneb was applied as a spray at the rate of 114 g chloroneb (Tersan SP) 65WP/14 L water per 93 m^2. An area of several hundred square meters in the immediate vicinity of the hygrothermograph was left unsprayed to verify predicted *Pythium* outbreaks.

RESULTS

Appearance of Pythium blight was always preceded by a warm day and a warm, moist night. Temperature at some period during the preceding day always exceeded 30 C and temperatures during the humid or wet period never fell below 20 C. Overall, our observations were in agreement with earlier reports (1,2,4–6) with regard to temperature and moisture conditions for Pythium blight occurrence.

When average duration of high humidity at various locations within a individual golf course was compared with the *Pythium* occurrence record, there was an obvious relationship between increased hours of RH ≥90% and blight occurrence (Table 1). In most instances, temperature differences among sites on an individual golf course were not statistically significant (Table 1). The one difference consistent among sites on an individual golf course was duration of high RH (Table 1). Turfgrass at all the golf courses received regular irrigation. Quantity of rainfall or irrigation bore no relationship to Pythium blight appearance. Duration of high moisture expressed as RH was more significant than quantity of precipitation. Irrigation that extended the consecutive number of hours that the RH was ≥90% occurred on two occasions, and Pythium blight appeared as forecast.

Chi-square analysis was performed on the 1979 data from four golf courses to test the relationship between specific weather variables and Pythium blight occurrence. The following weather variables were tested: amount of precipitation as rain or irrigation; minimum temperature ≤20C; RH ≥90%; maximum temperature ≥30 C; maximum temperature ≤30 C followed by RH ≥90% for at least 14 hr; maximum temperature ≥30 C followed by RH ≥90% for at least 14 hr; maximum temperature ≥20 C with RH ≥90% for at least 14 hr during the same period; and maximum temperature ≥30 C followed by RH ≥90% for at least 14 hr with minimum temperature ≥20 C during the same period. This last combination, employing both temperature and RH, was more effective than any of the previous variables. For example, at the three sites at Newtown Square during 300 forecasting days (100 × three sites), using the criterion of maximum temperature ≥30 C, *Pythium* was forecast on 114 days but actually occurred on only 23 days (25% accuracy). Using the criteria of minimum temperature ≥20 C with RH ≥90% for at least 14 hr during the same period, *Pythium* was forecast on 34 days and occurred on 25 days (74% accuracy). When the two variables were combined, *Pythium* was forecast correctly on 23 of 24 days (96% accuracy). Pythium blight occurred only once when it was not forecast (0.4% error).

In 1980, *Pythium* data from the most *Pythium*-prone area on each of the Pittsburgh, Verona, and Bethlehem courses were tested against the same set of environmental parameters. These results were very similar to the 1979 results (Table 2). Significant Pythium blight

Table 1. Average relative humidity (RH) and minimum and maximum temperatures within selected sites on three golf courses in 1978

Golf course site	Estimated Pythium risk[u]	RH[v,w] (hours >90%)	Average min. temp.[w,x] (C)	Average max. temp.[w,y] (C)	No. days Pythium occurred[z]
Pittsburgh					
1	High	12.6 a	14.2 a	25.9 a	7
2	High	13.5 a	14.0 a	25.1 a	7
3	High	13.9 a	13.9 a	24.4 b	8
Verona					
1	Low	6.0 a	13.8 a	25.2 a	0
2	Low	6.9 a	12.5 b	24.6 a	0
3	Moderate	9.5 b	12.5 b	23.7 b	3
Gladwynne					
1	Low	6.8 a	17.2 a	27.9 a	0
2	High	11.9 b	17.1 a	27.2 a	6
3	Very high	15.3 c	16.7 a	26.8 a	16

[u] Pythium risk perception as provided by the golf course superintendent at the time of initial hygrothermograph placement.
[v] Hours during the forecasting day when RH exceeded 90%. The value given is the mean of 100 forecasting days.
[w] Means in the same column for the same golf course followed by the same letter are not significantly different (Duncan's modified least significant difference test, $K = 100$).
[x] Average minimum temperature during a forecasting day.
[y] Average maximum temperature during a forecasting day.
[z] Presence of cottony mycelium in association with water-soaked blighted foliage.

Table 2. Contingency tables (2 × 2) to test the association of weather variables and occurrence of Pythium blight by chi-square test (χ^2) during 1979 and 1980

Location and year	Pythium occurrence	Number of forecasting days: Max. temp. ≤30 C	Max. temp. ≥30 C	Temp. ≥20 C RH ≥90% ≤14 hr	Temp. ≥20 C RH ≥90% ≤14 hr	One of criteria not satisfied	Both criteria satisfied
Newtown							
1979	No[a]	180	91	262	9	270	1
	Yes[a]	2	23	0	25	2	23
		$\chi^2 = 32.9$[b]		$\chi^2 = 210.4$		$\chi^2 = 257.9$	
Pittsburgh							
1979	No	212	64	264	12	274	2
	Yes	0	23	0	23	0	23
		$\chi^2 = 60.7$		$\chi^2 = 187.9$		$\chi^2 = 273.1$	
Verona							
1979	No	238	58	294	2	296	0
	Yes	0	3	0	3	0	3
		$\chi^2 = 11.8$		$\chi^2 = 178.2$		$\chi^2 = 299.0$	
Gladwynne							
1979	No	187	90	263	14	275	2
	Yes	3	16	0	19	3	16
		$\chi^2 = 20.7$		$\chi^2 = 161.8$		$\chi^2 = 217.0$	
Three Locations[c]	No	240	21	253	8	259	2
1980	Yes	3	29	2	30	5	27
		$\chi^2 = 137.13$		$\chi^2 = 207.7$		$\chi^2 = 223.4$	

[a] No = Pythium blight did not occur. Yes = Pythium blight occurred as indicated by presence of cottony white mycelium in association with water-soaked blighted foliage.
[b] $P \leq 0.0001$ in all cases except temperature at Verona, where $P \leq 0.0006$. All χ^2 tests of all variables rejected the null hypothesis (1 df). All variables were associated with disease occurrence but to different levels of expectations.
[c] Pittsburgh, Verona, and Bethlehem.

damage was prevented in areas treated with fungicide spray at the time critical weather criteria were met. In contrast, Pythium blight appeared in 27 of 32 unsprayed areas. Pythium blight symptoms appeared in the early morning or during the 24 hr after the first blight-favorable forecasting day.

DISCUSSION

On the basis of these studies, we propose that warm weather Pythium blight may be forecast using only a hygrothermograph and two observed criteria: 1) a maximum temperature higher than 30 C and 2) a critical period of RH exceeding 90% for 14 hr, during which time the minimum temperature remains higher than 20 C.

The instrument should be in a standard white weather shelter 15 cm above the surface. Several instruments are needed on each golf course, placement to be determined by the superintendent's knowledge of disease-prone areas and varying localized meteorological conditions. The system uses a noon-to-noon forecasting day, which normally includes both the daytime maximum temperature and the nighttime minimum temperature and high humidity period. Hygrothermographs are to be inspected each morning during conducive weather. When both criteria are satisfied, blight-prone areas should be sprayed as soon as possible.

Our work in some ways parallels the studies of Hall (4). In our judgment, his work may provide a basis for more precise forecasting, but the system would be detailed. Hall used temperature and humidity averaging techniques; he concluded that Pythium prediction could not be done at that time (1978). Our method, using the tested "critical period" technique, uses observations that are very easy to make and does not require sophisticated computation.

When using the system, one must be aware that other factors affect occurrence of Pythium blight, eg, surface water accumulation, time of day of irrigation, fertilizer applications, cultivation, and mowing. Irrigation and its effect on relative humidity are particularly important; late-afternoon or evening sprinkling should probably be avoided on very warm days.

ACKNOWLEDGMENTS

We thank David W. Smith, Professor of Statistics, North Dakota State University, Fargo, for assistance.

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