A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

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TURFGRASS PATHOLOGY

Anthracnose: A Problem in Tall and Short Cut Turf

By Christopher Sann, Turf Information Group Inc.

Anthracnose damage in turf, caused by the pathogen *Colletotrichum graminicola*, is a recognized major disease of closely mown, highly managed golf course and sports turf, but it is also an increasing problem with taller-cut, well maintained home lawns and commercial sites. A recognized problem on bentgrass and annual bluegrass stands for golf and sports turf managers, anthracnose often goes undiagnosed and unrecognized on many well managed fine fescue, bluegrass, ryegrass and tall fescue ornamental turfgrass sites.

As home lawn and commercial site turf managers become more sophisticated in their overall management practices and as the turf stands that they manage increase in leaf density, the microclimate turf canopy diseases like anthracnose, brown patch, and *Bipolaris* leaf spot are doing more damage. Unfortunately, because these diseases have not historically been well known in the ornamental turf industry, the negative impact that they have is rising. With that increase in damage has come an increased level of frustration by managers and the clients or bosses that they serve.

The frustration for any turfgrass manager of not knowing what is causing damage on a managed site is only surpassed by the embarrassment of admitting to the boss or client that you don't understand what has happened and you don't have a plan to stop it from happening in the future.

As with the concept in physics that "for every action there is an equal and opposite reaction," turfgrass managers need to understand that increasing the quality of the turf by increasing management inputs is not accomplished in a biological vacuum. As the leaf and plant density increases, the microclimate of the turf canopy changes. It becomes cooler and the humidity level rises. This, in turn, changes the types and populations of pathogens. A low- or moderate-maintenance site that has only supported low populations of the previously mentioned foliar diseases, can often sustain much higher pathogen populations that begin to produce damage symptoms — particularly when the host plants are stressed by low soil moisture, compaction, traffic or any condition or pest that adversely affects the efficiency or mass of the root system.

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Check the Symptoms

Anthracnose symptoms vary depending on the canopy's environmental conditions. The temperature range for active growth by *Colletotrichum graminicola* is from 52° F to 95° F with the optimum growth occurring between 77° F and 92° F. When temperatures are in the active growth range, the fungus spores will start to germinate following leaf wetness periods of as little as 24 hours. After 72 hours of leaf wetness germination of viable spores hits 100%, with the maximum tissue infection levels occurring in a range of 77° F to 90° F. (See "Leaf Wetness and Anthracnose Spore Germination.")

Under humid conditions at the warmer end of the temperature range and after prolonged leaf wetness periods, the pathogenís germinating spores attack plant leaves causing brown and yellow oblong lesions that, as they age, spread to span the leaf width.

As the infection progresses, the leaf tissue above the initial infection site turns yellow, then tan to light brown as it dies. As ideal or near ideal canopy conditions continue through successive pathogen generations, the plants' overall health become compromised and plants can begin to dieback in small irregular shaped patches.

If the site has an infection history and the plants are subject to a period of moisture stress following a period of leaf wetness, these small irregular patches can coalesce into large areas of blighted turf. Frequently, these blighted areas are misdiagnosed as moisture stress damage, but, unlike the effects of short-term moisture stress, plants subject to prolonged infection from anthracnose do not recover after the weather returns to more favorable conditions.

Under cooler, wet conditions at the lower end of the temperature range, the anthracnose spores can germinate further down the leaf structure at the plant's crown causing what is called a basal stem rot. The plants with infected crowns follow a dieback sequence similar to the foliar damage. Unlike the foliar symptom, however, the plant can be detached easily from its base with the tissue at the bottom of the plant exhibiting a black rotten color.

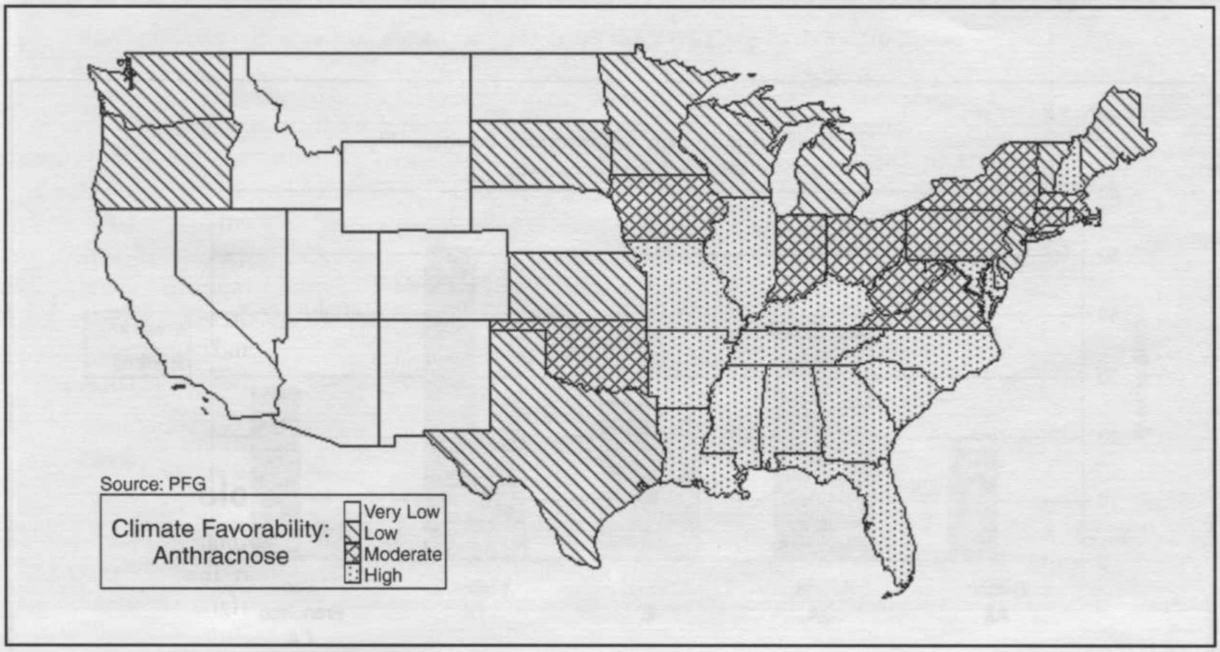
Unlike the foliar symptoms of warm, humid weather, death comes rapidly to plants affected by the basal stem rot phase of this disease. Recent research has indicated that the basal stem rot phase of this disease on golf course greens can be increased by frequent top dressing with sand or high sand content topdressing mixtures. The sharp edges of the sand particles damage the crown's tissue and these wounds act as multiple infection sites.

Pathogen biology

Colletotrichum graminicola is a very widespread fungus that infects many cereal grains as well as turfgrass. It survives long-term adverse conditions as saprophytic mycelium on dead leaf litter at the soil surface. During short-term adverse conditions, the pathogen survives as a black fruiting body or mass called acervuli. These fruiting bodies are small dark colored oval-shaped masses that can be seen on dead or dying infected plant tissue.

When more favorable conditions prevail, acervuli develop multiple black spines called setae that protrude from the mass. When active, the acervuli disperse the pathogen's crescent shaped one-celled spores, called conidia, that are spread to other leaves by traffic, wind, rain and irrigation. Once a spore has been subject to a minimum of 24 hours of wetness on a leaf surface, it germinates and the process starts over again.

Depending on the pathogen's phenotypes or genetic diversity and the climate at the site, anthracnose can affect stands of mixed turfgrass species differently. Despite the fact that fine fescues are the most vulnerable of the cool season grasses to anthracnose infection, it is not uncommon for the annual bluegrass in a mixed fine fescue/annual bluegrass stand to be hardest hit. In a bluegrass/ryegrass stand, the ryegrass may show damage while the bluegrass does not. In a bentgrass/annual bluegrass stand both species may show damage, while the same mixture at a second site may have only one species effected. This apparent



Climate favorability map for anthracnose.

resistance of one species over another may be a result of actual resistance or it may be that the damaged species was more stressed than the other and suffered the damage.

In taller-cut, unirrigated turf sites, anthracnose infections may require several years of favorable weather conditions to produce enough innoculum or pathogen population to develop identifiable symptoms under stress conditions. At frequently irrigated golf and sports turf sites, a damaging level of innoculum may develop rapidly, especially when plants become moisture stressed following prolonged rainfall.

Symptom expression is a function of site characteristics, the species being managed, the pathogen's site history, the range of phenotypes found at the site, the site's cultural practices, recent weather conditions and the density of available, viable anthracnose spores. Recent research concluded that not only are leaf wetness periods and temperatures important to symptom expression, so is the spore or pathogen concentration. When temperature (> 77° F for temperature) and leaf wetness (>24 hours for leaf wetness) are consistently in the favorable range, the higher the spore density and the greater the symptoms.

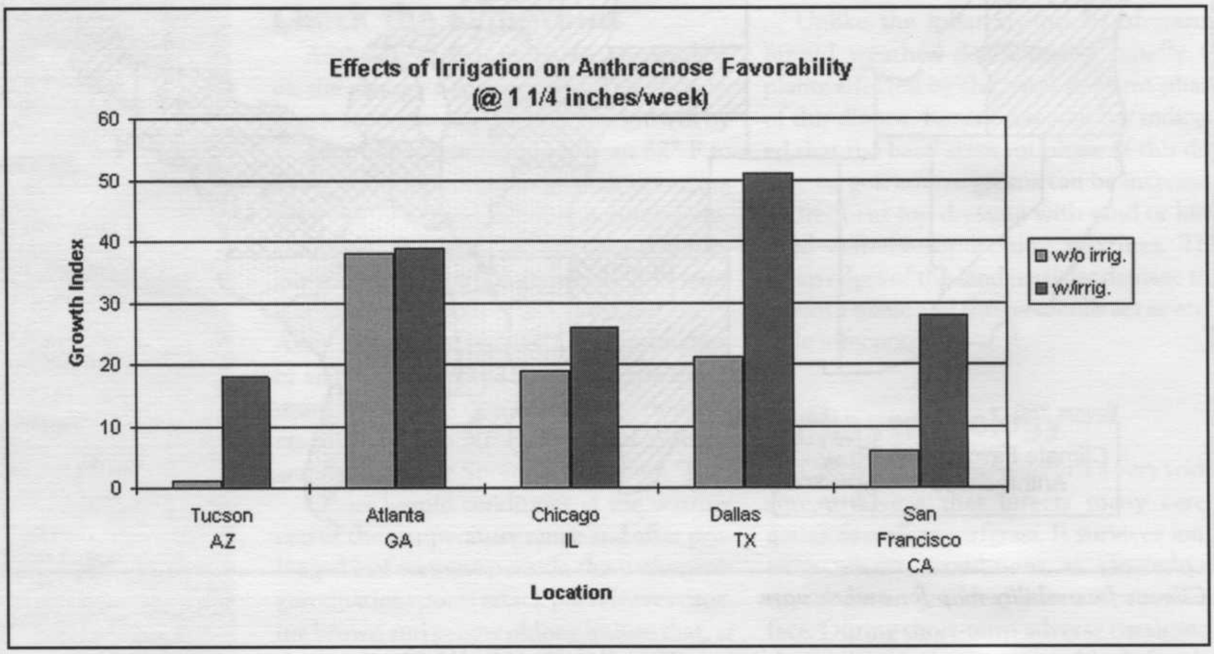
Where the disease ranges and favorable conditions

Because of the wide temperature range for active growth and the concurrent need of prolonged periods of leaf wetness, anthracnose is primarily a problem in areas east of the Midwest grain belt. It is a particular problem in the Southeast and along the Gulf Coast (see Climate Favorability Map above).

The Climate Favorability Map represents the annual climatic favorability for the growth of anthracnose. The value for a state is an average of the values for each region of each state, so managers should be aware that the favorability at a given location may vary from the average.

States that have consistently high rainfall and consistent temperatures in the growth range have high favorabilities. States where rainfall is consistent, but temperatures are not consistently in the growth range, will have moderate favorability. And states whose rainfall and temperatures are variable have low or very low favorability.

Within a region of a state, how a site is maintained can play a significant role in how much of a potential problem anthrac-



Graph1. Effects of Irrigation on Anthracnose Favorability.

nose poses. Graph 1 illustrates this point for locations where irrigation is used at managed sites.

The bar graph shows how 1.25 inches of irrigation per week during the summer changes the annual climatic favorability for anthracnose at five cities in the United States. Of the five cities shown, only the climatic favorability at Atlanta and Chicago was not substantially increased by increasing moisture.

In areas with sufficient moisture (like Atlanta and Chicago), adding additional water through irrigation does not increase the favorability significantly (+ 2% and + 30%). In drier climates like Tucson, Dallas and San Francisco, however, increasing moisture increased favorability by 1,000%, 250% and 400% respectively.

Site and soil can play role in symptom expression

Shaded or transitionally shaded sites with the accompanying longer leaf wetness periods can consistently support damaging populations. Drainage areas, downspout exhaust areas, areas with transient water flow, low areas and sites at the base of slopes are all vulnerable to infection, particularly after periods of consistent rainfall.

Areas with compacted or layered soil and areas with poor subsoil drainage are also areas vulnerable to anthracnose. Additionally, turf that has a shortened or compromised root system due to insect activity, soil-borne pathogen activity, poor fertility practices or frequent coring activity are all subject to intermittent anthracnose.

Finally, cultural practices that stress plants can lead to infection by anthracnose. Activities like low mowing, intermittent watering practices and reduced soil nutrient availability from failure to monitor and correct soil chemistry can all contribute by predisposing turfgrass to opportunistic infections.

Host susceptibility

At ornamental turfgrass sites, anthracnose is a problem on most managed species or varieties. Fine fescues are the most susceptible to infection with ryegrasses and tall

TABLE 1. ANTHRACNOSE RATINGS OF BENTGRASS CULTIVARS

Bentgrass cultivars grown on a green in 1997 @ OK site #1. Rating 1 - 9; 9 = No Disease

Name	*Rate*		
Lopes	8.7	Imperial	7.3
Penn A-1	8.3	Pennlinks	7.3
Penn A-4	8.3	SR 1020	7.3
Penn G-6	8.3	Lofts L-93	7.0
Regent	8.3	Msueb	6.7
Trueline	8.3	Penncross	6.7
Backspin	8.0	Mariner	6.3
Crenshaw	8.0	Penn G-2	6.3
Cato	7.7	Seaside	6.3
Century	7.7	18th Green	5.7
Pro/Cup	7.7	LSD Value = 2.3*	
Providence	7.7		
Southshore	7.7		

* — Plants whose value falls within a range of + or - the LSD value from a given cultivar are statistically equal to that cultivar.

fescues a distant second. Bluegrasses are the least vulnerable, but under suitable conditions, almost all of the grasses maintained at a higher cut can suffer significant damage.

On lower cut bentgrasses, cultivar resistance can be used to limit damage at sites with consistent problems or at sites where the occasional infections are difficult to deal with. Table 1 Shows the results of recent N.T.E.P. testing for anthracnose resistance among bentgrass cultivars.

How to diagnose anthracnose

Unlike many other turfgrass diseases diagnosing anthracnose is relatively easy. Finding acervuli with setae in several random grab samples is a strong probable indicator of current or near-term pathogen activity. This is particularly true if the acervuli with setae are found on green or yellow green leaves.

Acervuli without setae indicates a potential for disease activity, if the climatic conditions change to favor activity. Acervuli on leaf litter act as storage areas for spores that can be splashed or blown up on leaves or crowns for future germination.

Recommendations

Recent work at Michigan State and Ohio State universities indicates that symptom expression has a relationship not only to climate but also pathogen density (see "Leaf Wetness and Anthracnose Spore Germination). This can be used to estimate the relative likelihood that anthracnose will strike.

Although it is difficult to assign a threshold number of acervuli per grab sample, the relative number per leaf and the density of leaves with acervuli per sample is a good relative predictor of potential or current activity. A few leaves from a grab sample with a few acervuli without setae need occasional future scouting. Several acervuli with setae on several asymptomatic leaves following a rainfall require consistent monitoring and a change in any cultural practices that may be contributing to anthracnose favorability.

Multiple acervuli with setae with infected leaves in the sample need at least one fungicide treatment. And small to large areas of anthracnose damaged turf need multiple fungicide treatments and a change in cultural practices or site modification to avoid continued damage.

Changing cultural practices that cause plant stress can help reduce pathogen activity. Keeping a consistent mowing height, watering only when needed (not on a schedule), increasing soil nutrient availability, and monitoring and correcting soil chemistry can all work to reduce the impact of light to moderate infections.

Site modifications, such as improving subsoil drainage, reducing the amount and frequency of topdressing with sharp-edged sand, coring and verticutting only during periods of low potential pathogen growth, improving air and water flow and introducing more resistant cultivars can reduce the tendency of a site to harbor damaging pathogen populations.

Finally, at sites where anthracnose is a perennial and severe problem, change your expectations or change the site's usage parameters. Despite the fact that anthracnose is relatively easy to diagnose, stopping its negative consequences can be difficult. Early recognition of anthracnose at a site and developing a thorough understanding of the site conditions and cultural practices that contribute to the problem, are essential to controlling this disease.

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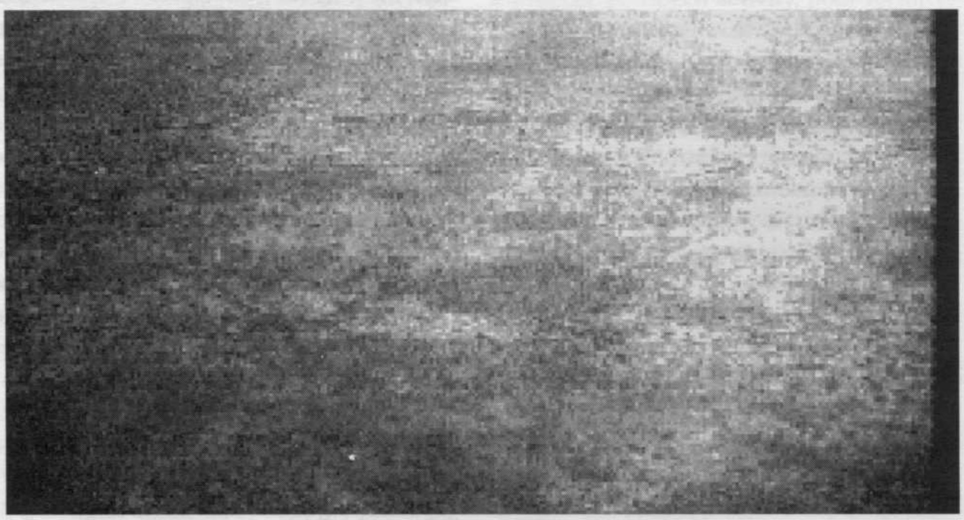
Setae growing from an acervuli.



Light colored bentgrass is infected with anthracnose.

Climatic Assessment

Of the Arid Southwestern United States for Use in Predicting Evapotranspiration of Turfgrass

By D.A. Devitt, D. Kopec, M.J. Robey, R.L. Morris, P. Brown, V.A. Gibeault and D.C. Bowman

Climate exerts a significant effect on the geographical distribution, growth and water use of plants. Climatic factors, such as precipitation, number of frost-free days, temperature (maximum, minimum, mean) and the distribution and amount of precipitation influence the geographical range of native vegetation.

Irrigated agricultural and non-agricultural plants, however, are not under the same limitations associated with precipitation events. Microclimates associated with agricultural and non-agricultural plants can also be modified to enhance plant survival and productivity (south facing slopes, wind machines, heaters, etc.).

M.Y. Nuttonson referred to areas of agricultural production with similar climates as ***agro-climatic analogues***. Growth, productivity, quality characteristics and evapotranspiration of plants growing in these agro-climatic analogues would thus be very similar, indicating that if a species is introduced to a similar agro-climatic analogue, there would be a good chance that it would respond in a similar fashion. Differences in plant response between analogues might still exist, however, due to the obvious effects of different cultural management, irrigation water quality and soil type.

The desert areas of Southern California, Arizona and Nevada, although not identical, were developed under similar climatic conditions and thus have many soil characteristics in common, according to the Soil Conservation Service. These include:

- poor profile development
- low soil organic matter content
- high soil strength
- and significant accumulation of salts and specific ions.

These desert regions are also dependent on the Colorado River and local groundwater sources to meet irrigation needs. The Colorado River carries a significant salt content which makes it necessary for irrigators to apply additional water to achieve leaching and maintain favorable salt balances in the soil profile (U.S. Salinity Laboratory Staff).

Greater information, based on scientific research, is needed in order to to make wise decisions concerning the allocation of water to provide adequate amounts that meet the requirements of both agricultural and nonagricultural crops.

The desert regions of Southern California, Arizona, and Nevada have significant acreage in turfgrass, including residential, commercial, and recreational uses. The combined turfgrass operations in these three areas represent in excess of a billion dollars annually (Cockerham and Gibeault). Bermudagrasses (*Cynodon dactylon*) grow well in these three areas because they are salt tolerant, drought tolerant, heat tolerant and become dormant during cold winter months. (Devitt, Gibeault, Kneebone, Pepper).

Populations continue to grow in the desert southwest, placing increasing pressure on available water resources. As such, water users are being scrutinized more closely, and in particular, turfgrass water users. Greater information, based on scientific research, is needed in order to make wise decisions concerning the allocation of water to provide adequate amounts that meet the water requirements of agricultural and nonagricultural crops.

If all three geographical areas were similar with regard to climate, soil, water quality and turfgrass response, the transfer of experimental findings from one area to another area could take place. Such transfer would save time and money by allowing water managers to make more accurate and timely decisions with regards to the water management of turfgrass. The objective of this research was to evaluate climatic conditions in Las Vegas, NV; Palm Desert CA; and Tucson, AZ over a two-year period and to assess the growing conditions for bermudagrass in all three areas to determine if these regions could be considered as agro-climatic analogues for bermudagrass (water use).

If all three geographical areas were similar with regard to climate, soil, water quality and turfgrass response, the transfer of experimental findings from one area to another area could take place.

Materials and Methods

Climatological data were gathered for the years 1988 and 1989 from official weather stations located in Palm Desert, CA (CIMIS); Tucson, AZ (AZMET); and Las Vegas, NV. Geodemographical information for each location is summarized in below. All three sites were equipped with automated weather stations (Campbell Scientific, Logan, UT) from which data was downloaded via a telephone modem to a computer. Meteorological variables monitored included relative humidity, temperature, wind run, solar radiation and rainfall.

The modified Penman Combination Equation was used to estimate potential evapotranspiration (ETo) at all three sites. ETo was based on hourly estimates at both the Palm Desert and Tucson sites, whereas ETo was based on daily estimates at the Las Vegas site. Crop coefficients (ET actual/ETo) used at each site were obtained from the literature for comparative purposes.

Information pertaining to the turfgrass industry, soil conditions, cultural management, and water quality at each location was obtained from local surveys conducted by the coauthors (Brown, Snyder, and Devitt). All dates (monthly and yearly) were analyzed using linear regression analysis, descriptive statistics and/or frequency distribution analysis (Dowdy and Wearden).

Results and Discussion

Location

The three study sites in this investigation are situated in a triangular geographic arrangement, sometimes referred to as the "Bermudagrass Triangle." Las Vegas is located approximately 341 km from Palm Desert and 663 km from Tucson. Tucson is located approximately 597 km from Palm Desert. All three sites have latitudinal coordinates between 32 and 36 degrees north.

ELEVATION, LATITUDE, LONGITUDE AND POPULATION

	Las Vegas, NV Clark County	Palm Desert, CA Coachella Valley	Tucson Pima County
Elevation(m)	659	56	710
Latitude	36-5	33-50	32-17
Longitude	115-10	115-30	110-57
Population (1994)	741,459	191,602	666,880

Elevation is slightly higher in Tucson than in Las Vegas and approximately 654 m higher than Palm Desert.

Edaphic Characteristics

The soils formed in all three areas are classified as either recently developed mineral soils with poor horizontal development (Entisols) or as mineral soils formed under an aridic moisture regime (Aridisols) Within these two soil orders can exist a great deal of variability with regard to both the physical and chemical status of the soil.

However, the majority of the soils at the locations are alluvial soils, alkaline in nature, classified as saline and often as saline-sodic soils before reclamation occurs. They have been reported to contain boron at levels detrimental to plant growth (U.S. Salinity Laboratory Staff).

Water

Total rainfall at all three location is inadequate to meet turfgrass water requirements. During 1988 and 1989, rainfall at Las Vegas averaged less than 6.5 cm per year, whereas Tucson averaged 22.6 cm per year. Rainfall occur-red primarily during winter and early spring at all three locations, but also during the summer months at Tucson and Las Vegas. Colorado River water supplied to all three locations possesses a salinity level of approximately 1.1 dS/m, whereas groundwater salinity levels range downward to 0.4 dS/m. The 1995 cost of water per 3,785 liters (1,000 gallons) for residential use was $0.98 to $1.16 in Las Vegas, $1.40 to $4.34 in Tucson, and $0.78 in Palm Desert.

The majority of the soils at the locations are alluvial soils, alkaline in nature and are classified as saline. They have been reported to contain boron at levels detrimental to plant growth.

Turfgrass Management

Bermudagrass is the predominant grass growing at all three location during the months of April through August/September. Golf turfgrass acreage has increased every decade since 1950.

Turfgrass systems in these areas are categorized as high maintenance or low maintenance, based on cultural management (Kopec and Mancino, 1990). Golf courses are classified as high maintenance turf, while most parts and schools are classified as low maintenance turf.

During the active growing season, high

MAJOR GRASSES, CROP COEFFICIENTS

	Clark County, NV	Coachella Valley, CA	Pima County, AZ
Major Grasses	Common Bermuda Ryegrass Tall Fescue Tifway Bentgrass	Common Bermuda Ryegrass Tifgreen Bentgrass *Poa trivialis*	Common Bermuda Ryegrass Tifway Bentgrass
Crop Coefficients	B/R HF = 0.71 B/R LF = 0.50 TF HF = 0.94	B = 0.60 R = 0.80	B HF = 0.75-0.8 B LF = 0.65 R HF = 0.75 - 0.90 R FL = 0.75 TF = 0.60

B/R - Bermuda/Ryegrass
TF - Tall Fescue
B - Bermudagrass
R - Ryegrass

HF - High Fertility
LF - Low Fertility

Devitt et al, 1992; Snyder 1986; Brown et al, 1988 maintenance turf would be cut daily or every other day and receive nitrogen at rates of 36.7 to 73.4 kg/ha/mo. Additional nutrients would also be applied as needed (micronutrients, phosphorus, potassium and sulfur). Low maintenance turf would be cut once or twice per week and receive little to no fertilizer input.

Most high maintenance turfgrass systems (bermudagrass) would be overseeded with ryegrass in early September or October, whereas low maintenance turfgrass systems would generally not be overseeded and would be allowed to enter full dormancy during winter months. Crop coefficients currently used for bermudagrass (high and low maintenance) at all three locations vary within a narrow range of each other (see table previous page). Crop coefficients for both Tucson and Las Vegas were based on research conducted at those locations. The crop coefficients used at Palm Desert were extrapolated from CIMIS data and were not based on research there.

Irrigation systems on high maintenance turfgrass are typically managed by a specialist who makes daily changes in irrigation amounts based on environmental demand (weather data, crop coefficients). The specialist is usually knowledgeable about sprinkler precipitation rates, uniformity distributions, soil infiltration rate and leaching requirements. Because high maintenance turfgrass typically receives better irrigation management than low maintenance turfgrass, efficiency in water use is higher, even though actual evapotranspiration is also higher due to increased growth and vigor (Devitt et al, 1992).

Most high maintenance (bermudagrass) would be overseeded with ryegrass in early September or October...

Climate counts

Monthly average values for maximum temperature, minimum temperature, average relative humidity, wind run and solar radiation measured at Las Vegas, Tucson and Palm Desert were charted. Both temperature and solar radiation varied with time in a sinusoidal fashion. Maximum temperatures averaged slightly higher in Palm Desert than in Tucson or Las Vegas, with the greatest divergence occurring during winter months. Average monthly minimum temperatures showed little deviation between sites, with Tucson recording slightly lower minimum temperatures during winter months.

However, the number of days on which minimum temperatures dropped below freezing varied significantly by location. Tucson averaged 31.5 days, Las Vegas 18 days, and Palm Desert 12.5 days.

Relative humidity and wind run showed greater variability among sites than was shown for temperature or solar radiation. Lower average monthly relative humidities were recorded during summer and higher average monthly relative humidities were recorded during winter at all three locations, with greater variation recorded at Tucson. Average monthly wind run was less variable than any other parameter on a monthly basis at all locations. Palm Desert averaged consistently lower monthly wind runs than Las Vegas or Tucson. Slightly lower wind runs were observed during winter at all three locations.

Potential evapotranspiration (ETo) was plotted on a monthly basis for all three locations. Estimates of ETo were very similar for all three sites during the months of October through April, with greater divergence occurring during the summer. Greatest separation in summer ETo estimates occurred during 1989, with Tucson having higher ETo than Las Vegas, which in turn had higher ETo estimates than Palm Desert

Higher wind runs combined with lower relative humidities during summer at both Tucson and Las Vegas resulted in higher ETo estimates, even though average maximum temperatures were higher at the Palm Desert site. This would indicate that during summer months at the three locations, the aerodynamic term in the Penman combination equation contributed significantly to the ETo estimates. ETo estimates for Tucson and Palm Desert were plotted against ETo estimates for Las Vegas. Both linear regressions were significant at the P=0.001 level, with the Tucson regression found above the 1 to 1 line and the Palm Desert regression found below the 1 to 1 line when monthly ETo estimates were above a value of 10 cm.

When Las Vegas ETo estimates were compared with the other two sites, a seven percent error was observed in estimating ETo for the Palm Desert site and a 13 percent error was observed in estimating the ETo for the Tucson site, where percent error was calculated by dividing the standard error of estimate (based on regression analysis) by the mean monthly ETo estimate at the Las Vegas site.

A slightly larger error (18 percent) was observed when estimates of ETo at the Tucson site were based on ETo from the Palm Desert site. Finally, frequency distributions were calculated for monthly ETo estimates (1988) based on mean daily ETo estimates reflecting the 95, 90, 75, 50 and 25 percent frequency distributions. Greater variability existed in the daily ETo estimates during most months of the year at the Tucson site compared to either the Las Vegas site or the Palm Desert site.

Greater variability in the daily ETo estimates (1988) at the Tucson site and the Las Vegas site occurred during April (transition month) and August (summer storms, cloud cover), whereas at the Palm Desert site greatest variability occurred during March and August.

Conclusions

Only slight differences existed between the average monthly minimum and maximum temperatures and solar radiation at the three sites. However, differences in average monthly wind run and relative humidity at the three sites led to greater separation in the ETo estimates during summer months. These differences resulted in a 7 percent and 13 percent error in estimating monthly ETo at the Palm Desert and Tucson sites respectively, based on using the Las Vegas monthly ETo data.

However, when Palm Desert monthly ETo data were used to predict ETo at the Tucson site, a slightly larger error of 18 percent was observed. Greater variability existed in the daily ETo estimates during most months at the Tucson site, compared to the other two sites.

This ETo variability combined with higher rainfall and a larger number of days in which temperatures dropped below freezing, would indicate that potential differences in the response of bermu-dagrass would be greatest if comparisons were made with the Tucson site.

Only slight differences existed between the average monthly minimum and maximum temperatures and solar radiation at the three sites. The three locations could be considered agro-climatic analogues for bermudagrass.

However, the 13 percent and 18 percent error in predicting ETo at the Tucson site based on data from either the Las Vegas site or the Palm Desert site is still low, indicating that the three locations could be considered as agro-climatic analogues for bermudagrass.

The fact that all three sites also used irrigation water of similar quality (Colorado River, groundwater, greater used of groundwater on golf courses in the Coachella Valley), the turfgrass is grown on poorly developed desert soils, and the turfgrass is maintained under similar cultural management (high or low maintenance turf) suggests that the growth and water use of bermudagrass (under similar cultural management) at any one of the three locations could be transferred and used at the other two locations, if consideration was given to the error in estimate and the time of the year. Finally, it should also be noted that such data should be continually reevaluated as larger data sets reflecting longer time periods are obtained.

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Taking Responsibility
For Golf Course Irrigation Systems

By Bruce F. Shank

Everyone knows the buck stops at the superintendent's desk for all aspects of maintaining a golf course's physical plant. However, there are certain special areas that the superintendent is more conscious of than others to insure his future at his course — namely greens, tees and fairways. Even though irrigation plays a key role in the condition of the "big three," it often does not receive the same priority or level of interest in the superintendent's mind. It is looked upon as an important component of the physical plant, but not as intriguing as a living organism.

The recent development of course management software for central irrigation controllers is challenging the perspective superintendents have of irrigation.

How can the superintendent handle public relations in the clubhouse when he is soaking wet? Is the assistant superintendent the appropriate person to keep a constant eye on the irrigation system? How about one of the crew foremen? There is a case against having any of these people making irrigation decisions on a daily basis.

Unique Team Member

The irrigation specialist needs to be as unique a member of the golf course "team" as the head mechanic. Smart superintendents know they can't micromanage the mechanic. By comparison, the same should be true for the irrigation specialist. Both deal with complex engineering. Both are responsible for hundreds of thousands of dollars in assets. Either person could shut down a golf course by not correctly performing his job. They are judged on how well they understand and manage machinery. Both are most concerned about equipment performing to specifications. They seem to overlook things like getting wet or entering a pump house in 100-degree heat.

Management by Computer

The recent development of course management software for central irrigation controllers is challenging the engineering perspective superintendent's have of irrigation. This software requires input and decisions from the superintendent. To intelligently understand how decisions made on a central controller impact the irrigation system, the superintendent must have a reasonable knowledge of its operation.

When a new control system is installed, superintendents can be found working seven days a week and late into the night inputing data on microclimates, turfgrass types, maintenance regimes, and pest and weed problems recorded in the past. The irrigation specialist should be included in this information loading process.

The controller is really a computer, not an irrigation clock anymore. It can keep track of equipment maintenance hours, degree days for pest control, crew overtime, and water and energy consumption. These are areas only a superintendent or his assistant fully grasp.

This pulls the superintendent back into closer management of irrigation. It demands a total manager's input. Ultimately, it does not reduce the importance of assigning a specialist to "tune" and "sharpen" irrigation performance. A computer can't repair a faulty valve or head, just report it. A computer can't tell if runtimes are causing wilt symptoms on fairways, even when moisture sensors are there to prevent that from happening. A computer might detect a problem with slipping sprinkler uniformity, but it can't fix it.

Constant Attention

While Detroit now makes cars that don't need a tuneup for 100,000 miles, that's not how an irrigation system works. Two days of improper irrigation can destroy acres of turfgrass. You can't take people out of the irrigation management equation. Neither can you buy a piece of equipment to appreciate when bentgrass is reaching its stress tolerance point. A person who is familiar with the microclimates of the course, the history of problems, and the amount of traffic from day to day is essential to maintaining top playing quality.

So, before your next big tournament, call a meeting with your assistant(s) and irrigation supervisor to discuss just the subject of irrigation. Go over course condition, water and energy budgets and how irrigation impacts the success of the course. Bring in your local irrigation consultant, architect or distributor rep for their ideas.

Set goals. Meet regularly with your course irrigation "committee" to see if those goals are being reached. Always keep the irrigation specialist in the loop.

Growing in Importance

The cost and importance of water to golf in the future will dictate that all superintendents be knowledgeable about irrigation and the hardware and software that makes it work. That doesn't mean, however, that the superintendent or his assistants should have daily responsibility for irrigation system performance. Nor does it mean they should micromanage. Each individual should concentrate on his immediate set of responsibilities and delegate essential maintenance to those who are trained and focused on specific areas.

Irrigation is becoming the center piece of golf course operations because it is computerized. Chemigation, fertigation, recycled water and course management software, all bring attention back to irrigation. Weather data can be fed into the central controller with other sensor data to help correct for macro- and micro-climates.

The superintendent and his irrigation consultant or supplier can check system operations by calling the computer through a modem. Attention on all matters, not just irrigation take on a much more informed status. Adjustments can be made any time from nearly anywhere.

Education is a Must

These things only emphasize the need for trained irrigation specialists in the golf course industry. While manufacturers and distributors offer training opportunities, the irrigation specialist depends largely on on-the-job training.

Because of this, his experience might be limited to one type or one manufacturer's system. His level of knoweldge limits his capacity to handle new or retrofitted systems.

Golf course superintendents should encourage training for irrigation specialists and have their courses share training and necessary travel expenses. The number of irrigation classes offered at the Golf Course Superintendents Association of America Show has doubled.

The Irrigation Association now provides a golf course seminar during its annual conference. Toro, Legacy/Hunter. and Rain Bird have irrigation schools during the year. Both the IA and manufacturers offer regional training events hosted by irrigation distributors. The United States Golf Association Green Section also provides irrigation support during its regional seminars.

Even basic irrigation courses in electrical troubleshooting, irrigation auditing, and valves can provide important information useful to prevent or correct emergencies. Conversely, advanced courses on managing salinity, using recycled water and calculating evapotranspiration rates from local universities can round out the specialist's knowledge.

Look for more educational opportunities in irrigation to be available in the coming months and years. Explore web sites and search engines for training purposes. Many of these can be found through *www.irri-gate.com*. This is a search engine devoted entirely to irrigation.

Bruce Shank is the owner of Irricom, a research and public information contractor to the Irrigation Association and does layout and production for TurfGrass TRENDS.

Anthracnose Infestation

Leaf Wetness, Temperature, and Spore Concentration

By Christopher Sann, Turf Information Group Inc.

In 1993 three researchers, J. M. Vargas and A. L. Jones of MSU and T.K. Danneberger of OSU released the results of their research on the relationship between leaf wetness, temperature and spore concentration on anthracnose infection of annual bluegrass. This research offers dramatic insight into under what conditions this disease develops, how its occurrence might be anticipated, and how cultural practices might be altered to reduce infection.

The Research

Four different concentrations of spores (1,000, 10,000, 100,000 and 1,000,000 spores per milliliter) were applied to samples of annual bluegrass that were being raised in growth chambers. The experiments were conducted at four temperatures (59° F [15 C], 68° F [20 C], 77° F [25 C] and 86ç F [30 C]) for five leaf wetness periods (0, 12, 24, 48, 72 hours). After the predetermined period in the growth chamber, the samples were removed and a sample of 200 spores from each were checked to see if they had germinated.

When the results were tabulated, it was found that no significant germination occurred at 0 hours, 59° F (15 C), or at a concentration of 1,000 spores/ml. But as the two graphs at right illustrate, germination for the other temperatures, wetness periods and concentrations was significant.

At all temperatures and hours of leaf wetness, germination at the 10,000 spores/ml concentration was less than 20%.

At the two highest concentrations and temperatures, significant germination that might lead to symptoms (at or > 40% began to appear after only 24 hours of leaf wetness. At 48 hours, the two highest concentrations were all > 40% and averaged ~83%. At 72 hours, the average germination for the two highest concentrations was ~ 94%.

What the results mean

Although the research cited here measured germination and not symptomology, depending on the site history, it can be used as an excellent gauge to the eventual expression of symptoms.

Leaf wetness periods of greater than 48 hours pose the highest level of risk for the development of an active anthracnose infestation for any site that has vulnerable cultivars, particularly at those sites with the greatest population concentrations.

Close behind in risk is a wetness period of greater than 24 hours at any site that has a significant history of anthracnose infestation.

Recommendations

Since those states identified on the Climate Favorability Map on page 3 as having moderate to high risk for anthracnose each have a period of months each year with significant climatic favorability (15 to 66% of the year based on normal climate conditions), managers in these states need to be aware that anthracnose may be active from ~ 2 to 8 months per year on vulnerable cultivars and sites with a history of this disease.

Culturally, it is very important that irrigation be flexible enough so that, during or just after periods of prolonged precipitation, leaf wetness is not extended by unnecessary watering. Increasing air flow and site drainage in humid or wet season climates may help shorten leaf wetness periods and there by reduce disease incidence. Where possible changing or introducing cultivars with more resistance may also reduce symptom expression. And, the use of materials like wetting agents applied to foliar surfaces to reduce leaf wetness may have some beneficial effects.

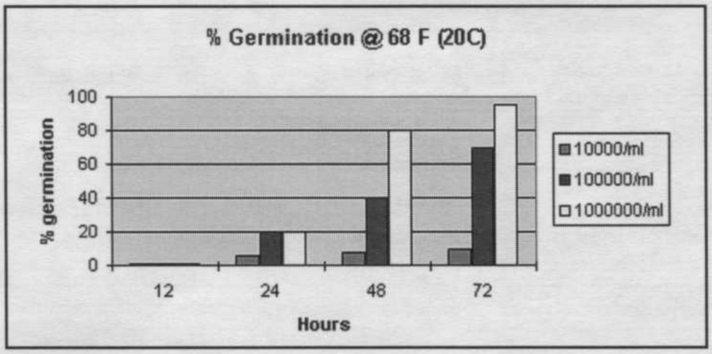
Finally, since populations of this disease are so readily identifiable and quantifiable (by examining grab samples to look for acervuli with or without setae), fungicide treatments can be timed for maximum results.

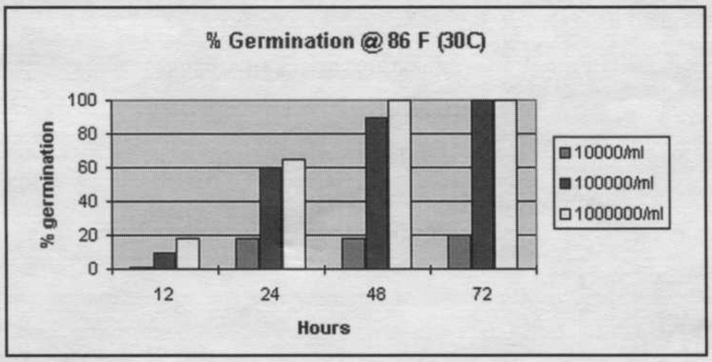
Fungicide strategies

At vulnerable sites in states with multiple months of climatic favorability, systemic fungicides alternated or augmented with contact fungicide materials and with applications commencing at the first sign of acervuli activity (the formation of setae) is probably the best overall strategy.

In states with only several months of potential activity, several applications of contact fungicide materials applied at the earliest sign of acervuli activity may be sufficient to minimize pathogen activity.

At all locations, periodic grab samples of leaves and thatch or duff should be taken to monitor acervuli populations. Low acervuli numbers or low densities when compared to leaves should always be maintained because extended periods of leaf wetness comprising 24 to 72 hours are very common throughout the disease's active growth range of 51° F to 93° F. Management strategies should be designed and implemented to minimize the chances that high acervuli populations develop, because as the research shows, germination and infection under high spore concentrations may be a foregone conclusion.





Percent germination of spores in a growth chamber at 68° (top) and 86° (bottom).

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