Evaluation of Pathogenicity of *Bipolaris* and *Curvularia* spp. on Dwarf and Ultradwarf Bermudagrasses in Florida

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**Abstract**

Isolates of *Curvularia lunata*, *C. geniculata*, *Bipolaris hawaiiensis*, and *B. cynodontis* were tested for pathogenicity on the hybrid bermudagrass cultivars Tifdwarf, TifEagle, and FloraDwarf at 20 and 30°C. *Curvularia lunata*, *C. geniculata*, and *B. hawaiiensis* produced some minor leaf tip necrosis at the cut ends of leaves 24 to 48 h after inoculation. *Bipolaris cynodontis* produced significant tip dieback and leaf spotting on all three cultivars at both 20 and 30°C, and disease severity was higher at 20°C than at 30°C. With *C. lunata*, *C. geniculata*, and *B. hawaiiensis*, occasional leaf-spotting occurred only on senescing, older leaves. *Bipolaris cynodontis* is considered pathogenic on bermudagrasses, while *C. lunata*, *C. geniculata*, and *B. hawaiiensis* are considered senectopathic, able to incite disease only in senescing plant tissue. *Curvularia lunata* and *B. hawaiiensis* resulted in higher disease severity at 30°C than at 20°C, indicating that these species are senectopathic at higher temperatures.

**Background**

In the past ten years, an increasing number of golf course putting greens have been planted with new “ultradwarf” hybrid bermudagrass (*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy) cultivars, including ‘FloraDwarf’ and ‘TifEagle,’ due to their perceived tolerance for lower mowing heights that promote a more consistent and longer ball roll (10). A golf course monitoring program in summer of 2000 in Alabama, Florida, Louisiana, and Mississippi reported significant disease problems and decline in ultradwarf bermudagrass putting greens (20). Diagnostic labs, which received turfgrass samples from the scouting program, identified *Curvularia* spp. as the foliar fungus implicated as the primary concern (20).

Various descriptions of turfgrass problems associated with *Curvularia* spp. have been given, ranging from small, tan to brown patches that coalesce (4,19) to a general decline and thinning in turfgrass subjected to heat stress (17). Descriptions on individual plants also vary (13), but include an initial yellow-green dappling of leaves, followed by chlorosis and leaf tip dieback, with or without a distinct margin between healthy and affected tissue (17). Individual leaf lesions were observed on some turfgrass species when inoculated with some isolates of *Curvularia* spp. (3).

Conflicting results from different studies with several species of *Curvularia* on various turfgrass species has led to questions about whether *Curvularia* spp. can cause disease on bermudagrass, and if they are responsible for the periodic declines of golf greens referred to by some diagnosticians and superintendents as “Curvularia blight.” However, when conclusions of these various inoculation studies are summarized (Table 1), a pattern emerges: *Curvularia* spp. are only associated with more severe disease problems at higher temperatures (> 25°C) or when plant tissue is older and/or senescent. Inoculated turfgrass species subjected to lower temperatures show either no symptoms or only some slight leaf tip dieback and chlorosis which may be associated with cut (wounded) leaf
tips. Couch (4) described the *Curvularia* spp. as senectophytes, organisms that can only incite disease in senescent tissue. Couch (4) further defined senectopathic disorders in turfgrasses as biotically incited diseases that develop only after plant tissue is in advanced senescence.

Table 1. Summary of symptomatology at different experimental temperatures for pathogenicity experiments involving *Curvularia* spp.

<table>
<thead>
<tr>
<th><strong>Curvularia</strong> sp.</th>
<th><strong>Turfgrasses tested</strong></th>
<th><strong>&lt; 25°C</strong></th>
<th><strong>≥ 25°C</strong></th>
<th><strong>Ref</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. protuberata</em></td>
<td><em>Poa pratensis</em></td>
<td>no symptoms</td>
<td>leaf tip dieback, leaf spots, general blighting of crowns</td>
<td>Brown et al. 1972 (3)</td>
</tr>
<tr>
<td><em>C. Intermedia</em></td>
<td><em>Festuca rubra</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. Lunata</em></td>
<td><em>Agrostis palustris</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. geniculata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. trifolii</em></td>
<td><em>Poa annua</em></td>
<td>leaf tip dieback, some chlorosis</td>
<td>severe tip dieback, leaf sheath lesions, and dead leaves</td>
<td>Falloon 1975 (5)</td>
</tr>
<tr>
<td><em>C. lunata</em></td>
<td><em>Agrostis palustris</em></td>
<td>some leaf tip chlorosis in older leaf tissue only</td>
<td>chlorosis, severe in older leaf tissue</td>
<td>Muchovej 1986; Muchovej &amp; Couch 1987 (12,13)</td>
</tr>
<tr>
<td><em>C. inaequalis</em></td>
<td><em>Zoysia japonica</em></td>
<td>n/a</td>
<td>leaf tip dieback, chlorosis and leaf sheath lesions</td>
<td>Kim et al. 2000 (9)</td>
</tr>
<tr>
<td></td>
<td><em>Agrostis stolonifera</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cynodon dactylon</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lunata</em></td>
<td></td>
<td>n/a</td>
<td>low levels of chlorotic or necrotic tissue</td>
<td>Pratt 2000 (14)</td>
</tr>
<tr>
<td><em>C. geniculata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

x Some earlier studies prior to 1972 are summarized by Brown et al. (3).

y n/a = not applicable; treatment was not included in experiments.

In addition to the studies summarized in Table 1, Hodges and Madsen (7) inoculated *C. geniculata* (Tracy & Earle) Boedijn and *B. sorokiniana* (Sacc.) Shoemaker (=Dreschlera sorokiniana) alone and in combination on *Poa pratensis* L. at 20, 25, 30, and 35°C. *Curvularia geniculata* alone produced minimal disease at all temperatures, with < 2% of tissue diseased. However, there was a synergistic interaction at 30°C in that disease severity was significantly higher when the two species were co-inoculated than when either species was inoculated alone. Hodges and Madsen (8) later concluded that this synergistic disease response at 30°C occurs only on the oldest senescent leaves and is likely the result of increased saprophytic growth (but not increased virulence) of *C. geniculata* at higher temperatures.

On the other hand, pathogenicity of several *Bipolaris* spp. has been clearly established on bermudagrass (4,17). Bipolaris leaf spot caused by *B. cynodontis* (Marignoni) Shoemaker is considered to be of major importance; this species infects during cool wet weather and may cause extensive damage when it attacks crowns, stolons, or rhizomes (4,17). *Bipolaris hawaiiensis* (M.B. Ellis) Uchida & Aragaki has been shown to infect bermudagrass used for forage (15), but is considered to be of minor importance in turfgrass species (17). The primary objective of this study was to determine whether species of *Bipolaris* and *Curvularia* found in a survey of Florida golf course putting greens are pathogenic to bermudagrass.

**Inoculation of Hybrid Bermudagrasses**

Isolates of *Curvularia* and *Bipolaris* spp. were obtained from ultradwarf bermudagrass golf course putting greens in Florida during a survey in 2003 and 2004 to identify potential pathogens and environmental factors associated with decline of ultradwarf greens (Fig. 1) (2). Isolates were identified to species level...
based on the criteria described by Sivanesan (16) and comparison to ATCC cultures, including *B. cynodontis* 58455, *B. hawaiiensis* 44755, *C. geniculata* 6671, *C. lunata* 42205, and *C. senegalensis* 24154.

Isolates of *B. cynodontis*, *B. hawaiiensis*, *C. geniculata*, and *C. lunata* were single-spored and maintained long-term on filter paper as follows. A mycelial agar disc, 5 mm in diameter, was cut from a 3-day-old actively growing single spore fungal culture on ½-strength potato dextrose agar (PDA) and placed onto another plate of ½ PDA containing a sterilized piece of filter paper. Once the fungal isolate colonized the filter paper, the paper was removed and placed into a sterilized coin envelope and dried overnight in an oven at 40°C.

Experiments on the pathogenicity of *B. cynodontis*, *B. hawaiiensis*, *C. geniculata*, and *C. lunata* (Wakk.) Boedijn were conducted in 2004 in greenhouses and growth chambers. The bermudagrass cultivars Tifdwarf, TifEagle, and FloraDwarf were chosen as a standard dwarf type and two new ultradwarf types, respectively. The bermudagrass cultivars were planted into 10-cm-diameter plastic pots (10 two-node sprigs per pot) containing a sterilized (6) greens mix of 85% sand and 15% sphagnum peat moss and placed on a misting bench for 7 days. Plants were then grown in a greenhouse maintained at 25 ± 3°C for 5 to 7 weeks to allow for complete pot coverage. The grass was then divided, transferred to 5-cm-diameter pots and grown for 15 days. Grasses were fertilized weekly by adding 5 ml per pot of the following solution: ammonium nitrate (18 g/liter), diammonium phosphate (2.7 g/liter) and potassium nitrate (6 g/liter) (to provide N at 48.8 kg/ha, P at 12.2 kg/ha, and K at 24.4 kg/ha). Turfgrass was clipped regularly to encourage prostrate growth and coverage and maintained at a height of cut of 5 mm.

Inoculum for foliar experiments was obtained by placing five 2-mm² pieces of colonized filter paper of single isolates of *B. cynodontis* (BeCG2), *B. hawaiiensis* (BhIB6), *C. geniculata* (CgLK1), and *C. lunata* (ClLM2) onto petri plates of ¼-strength PDA that were incubated at 25°C for 14 days with cool white fluorescent lighting for 12 h daily. On the day of inoculation, the petri plates were flooded with 5 ml of sterile distilled water. Conidia were dislodged by carefully scraping the fungal colony with a rubber policeman, and the resulting conidial suspension filtered through three layers of cheesecloth. The conidial suspension was then adjusted to a concentration of 5.0 × 10⁴ conidia per ml. The surfactant Tween 80 was added in the amount of 250 µl per liter of conidial suspension to aid in dispersion of inoculum on the leaf surfaces.

Prior to inoculation, bermudagrass leaves were clipped using a sharp pair of shears. Inoculations were made using an aerosol sprayer (Crown Spra-Tool, Fisher Scientific, Pittsburgh, PA), and the conidial suspension was applied until leaf run-off. Untreated controls were sprayed with just sterile water and Tween 80 suspension. A polyethylene bag was placed over each inoculated pot to maintain high relative humidity and pots remained inside the bags for the duration of the experiment of five days. Plants were placed in growth chambers that were adjusted to temperatures of 20 and 30°C.

For foliar inoculations, disease severity was rated daily for five days on a 1 to 6 scale using a slight modification of a previously published method (5), where 1 = no symptoms, 2 = 0 to 2 mm leaf tip die-back, 3 = 2 to 4 mm leaf tip die-back and/or less <1% chlorotic leaf lesions, 4 = leaf tip die-back plus < 5%
chlorotic leaf lesions, 5 = leaf tip die-back plus 5 to 50% leaf lesions, and 6 = > 50% leaf necrosis and blighting of leaves. A disease severity rating of at least four or higher was considered as pathogenic, due to the presence of numerous distinct lesions and detrimental affect to plant health. Pots were arranged in a completely randomized design with four replications per treatment, and the experiment was completed twice. Data were analyzed by performing square root transformation on disease severity ratings of leaves before analyzing data by Fisher’s protected LSD test or the Student-t-test where appropriate using SAS for Windows version 8.2 (SAS Institute Inc., Cary, NC).

Ten leaves of each treatment were sampled 24, 48, and 120 h after inoculation in order to determine germination of conidia and the ability of the fungi to invade leaf tissue. Symptomatic leaf tissue was surface sterilized for 1 min in 0.063% sodium hypochlorite with 0.5 ml of Tween 80 per 100 ml of solution. Leaf tissue was then rinsed three times in sterilized water, blotted dry with sterilized paper and ten pieces (5 per plate) were plated out on ¼-strength PDA amended with antibiotics (200 ug/ml streptomycin sulfate and 5 ug/ml rifampicin, both from Sigma Chemical Co., St. Louis, MO).

Symptomatic leaf tissue was also cleared for 1 week in a 1:1 solution of glacial acetic acid and 95% ethyl alcohol (1,13). Staining of leaf tissue was prepared using 0.25% aniline blue in lactophenol (10 ml deionized water, 10 g glycerin, 10 ml lactic acid, and 10 g phenol) and mounted onto glass slides for light microscope observation for the presence of mycelium (1,13).

**Foliar Symptomatology, Microscopic Observations, and Disease Severity**

All four fungi produced some minor leaf tip necrosis at the cut ends of leaves 24 to 48 h after inoculation; however, leaf tip necrosis did not progress any further than 4 mm even after five days (Figs. 2A and B). The cut ends of leaves of non-inoculated control plants were mostly yellow to light brown in color and extended only about 1 mm (Fig. 2C). Occasionally there was less than one percent leaf spotting on the older leaves when plants were inoculated with *B. hawaiiensis*, *C. geniculata*, and *C. lunata* (Fig. 2D). *Bipolaris cynodontis* was the only fungus to cause considerable leaf spotting on both juvenile and mature leaves (Fig. 2E). At 20°C, the leaf spot lesions caused by *B. cynodontis* were more numerous and distinct (Fig. 2E) than the lesions formed at 30°C, which were more nondescript and exhibited more chlorosis than necrosis (Fig. 2F). Mycelia were observed macroscopically coming out of the cut leaf tip 48 h after inoculation with all the fungi tested, but not in the non-inoculated controls. When inoculated plants with symptoms of leaf tip necrosis were plated onto media only the original inoculated fungus was recovered, while 20% of control plants produced colonies of *Fusarium* sp. and *Cephalosporium* sp. Plants inoculated with *B. hawaiiensis*, *C. geniculata*, and *C. lunata* also appeared somewhat more chlorotic than the non-inoculated controls (Figs. 3 and 4), but there were no individual leaf spots or significant dieback on non-senescing tissue.
Fig. 2. Stereoscopic images of various bermudagrass leaf symptomatology. Example of common leaf tip necrosis of cut leaves 24 to 48 h after inoculation with Bipolaris spp. and Curvularia spp. tested at 30°C (A and B); no leaf tip necrosis present at cut ends in non-inoculated control (C); occasional leaf tip necrosis with some minor leaf spotting on older leaves caused by B. hawaiensis, C. geniculata, and C. lunata (D); typical leaf spotting on juvenile and mature leaves caused by B. cynodontis 120 h after inoculation at 20°C (E); and leaf spotting symptoms of B. cynodontis 120 h after inoculation at 30°C (F).

Fig. 3. ‘TifEagle’ bermudagrass inoculated with C. lunata (left) and non-inoculated (right).

Fig. 4. Close-up of ‘TifEagle’ bermudagrass inoculated with C. lunata, illustrating leaf tip dieback and chlorosis of some leaves.
Leaves with leaf tip necrosis and lesions were cleared and stained to observe conidial germination, mycelial growth, and colonization of the tissue (Figs. 5 A to D). Examination of conidia on leaf tissue of all the fungi tested indicated a germination rate of 90% or higher after 24 h. All fungi readily colonized the cut end of leaf tips and other leaf injuries; however, the fungal ingestion into the leaf tissue was only detected where necrotic tissue developed (Fig. 5A). Mycelia of *B. hawaiiensis*, *C. geniculata*, and *C. lunata* quickly spread on the surface of the leaf and occasionally formed appressoria-like structures over stomata; however, they were unable to penetrate or cause lesions in young leaves (Fig. 5B). Mycelia were present on the surface of the leaves and in the immediate leaf tip necrotic tissue and appeared to be growing as saprophytic organisms. Sometimes on older senescing leaf tissue, the appressoria-like structures could cause a localized lesion that did not expand. The cells immediately surrounding the stomata were chlorotic to necrotic and may have been a result of a hypersensitive response by the plant to the recognition of some fungal metabolite. However, no observations of mycelium were detected inside the leaf tissue of these localized lesions when evaluated with light microscopy (Fig. 5C). Mower (11) and Muchovej (12) also could not find any internal hyphae in areas of symptom development of creeping bentgrass and Kentucky bluegrass when inoculated with *C. lunata*.

![Fig. 5. Light microscopic images of various bermudagrass leaf symptoms. Example of common leaf tip necrosis and saprophytic mycelium 96 h after inoculation with *Bipolaris* spp. and *Curvularia* spp. tested (A); mycelia of *B. hawaiiensis*, *C. geniculata*, or *C. lunata* spreading across a leaf blade 96 h after inoculation at 30°C and the occasional formation of non-penetrating appressoria-like structures formed over stomata (B); typical leaf spot caused by *B. hawaiiensis*, *C. geniculata*, and *C. lunata* on older leaves at 30°C (C); and typical leaf spot caused by *B. cynodontis* 24 h after inoculation at 20°C (D).](image)

On the other hand, conidia of *B. cynodontis* quickly germinated and produced leaf lesions within 24 to 48 h of inoculation by forming appressoria, usually over stomata; necrosis occurred in the immediate surrounding cells, resulting in dark brown small lesions which did not continue to expand (Fig. 5D). This fast-acting lesion formation may be due to a phytotoxic reaction caused by bipolaroxin, a toxin secreted by some isolates of *B. cynodontis* (18). However, no observations of mycelium were detected inside the leaf tissue of these lesions until the leaf had entered into an advanced state of senescence.
marked by a general chlorosis of the leaf blade and necrosis around the point of ingress.

Foliar disease severity ratings also provided evidence that *B. cynodontis* is pathogenic on bermudagrass, while *B. hawaiiensis*, *C. lunata*, and *C. geniculata* are senectopathic. At both 20 and 30°C, mean disease severity ratings for *B. cynodontis* were significantly higher than the other three species and the uninoculated control (Fig. 6). Disease ratings for *B. cynodontis* also were above a rating of four, the level at which significant leaf spotting begins to occur based on the rating scale. *Bipolaris cynodontis* caused significantly higher disease ratings at 20°C than at 30°C (*P* ≤ 0.05) (Fig. 7). In contrast, *B. hawaiiensis* and *C. lunata* both had significantly higher disease ratings at 30°C than at 20°C (*P* ≤ 0.05) (Fig. 7), however the mean disease ratings was still less than four on the rating scale.

Fig. 6. Comparison of foliar disease ratings at five days after inoculation with *B. cynodontis*, *B. hawaiiensis*, *C. geniculata*, *C. lunata*, and the control at 20 and 30°C for combined experiments and cultivars. Bars with the same letter within temperature regime do not differ significantly at *P* ≤ 0.05 as determined by Fisher’s protected LSD test using square root transformation of the disease rating values. Rating scale as follows: 1 = no symptoms, 2 = 0 to 2 mm leaf tip die-back, 3 = 2 to 4 mm leaf tip die-back and/or less <1% chlorotic leaf lesions, 4 = leaf tip die-back plus <5% chlorotic leaf lesions, 5 = leaf tip die-back plus 5 to 50% leaf lesions, and 6 = >50% leaf necrosis and blighting of leaves.

Fig. 7. Comparison of foliar disease ratings at two temperatures, five days after inoculation with *B. cynodontis*, *B. hawaiiensis*, *C. geniculata*, *C. lunata*, and the control, for combined experiments and cultivars. Bars with the same letter within the fungal grouping do not differ significantly at *P* ≤ 0.05 as determined by Student t-test using square root transformation of the disease rating values.
When the bermudagrass cultivars were compared for disease response, FloraDwarf had significantly higher disease ratings in comparison to Tifdwarf and TifEagle when inoculated with *B. cynodontis* (*P* ≤ 0.05) (Fig. 8). FloraDwarf developed significantly more tip dieback than TifEagle and Tifdwarf when inoculated with *C. lunata* (*P* ≤ 0.05); however, the mean disease ratings were less than four for all cultivars (Fig. 8).

**Senectopathic Versus Pathogenic Species**

Growth chamber inoculation studies demonstrated that isolates of *B. hawaiiensis*, *C. geniculata*, and *C. lunata*, originally obtained from declining bermudagrass golf greens, are not pathogenic to healthy FloraDwarf, Tifdwarf, or TifEagle bermudagrass cultivars. When incubated at 20 or 30°C, mean disease ratings for plants inoculated with these three species were less than four, the level at which significant leaf tip dieback and individual leaf spots occur. Under non-stress conditions, these fungi were able to invade juvenile or mature leaves only at the cut ends or other leaf wound sites causing a brown to black leaf tip necrosis that did not extend more than 4 mm down the leaf blade. In addition, uninoculated control plants did not show any leaf tip necrosis; *Fusarium* spp. and *Cephalosporium* spp. were obtained from 20% of the control plants, but not from inoculated plants. This suggests the inoculated senectopathic species out competed saprophytic fungi in the senescing plant tissue at the cut leaf tips.

Leaf tip necrosis did not have a detrimental effect to plant health and occasional leaf lesions mostly formed on senescing tissue. Therefore *B. hawaiiensis*, *C. geniculata*, and *C. lunata* are not considered to be pathogenic but rather senectopathic (4). Similar results were obtained when Muchovej and Couch (13) inoculated bentgrass that was clipped at varying intervals (0 to 128 h) prior to inoculation with *C. lunata*. Leaf tip chlorosis developed beginning at the clipped end, then progressed downward. However, there was very little chlorosis in inoculated 30-day-old plants except when the plants were subjected to high temperature stress (38°C for 18 h) just prior to clipping. Leaf tip chlorosis was more severe in 120-day-old plants, even without a high temperature stress, and chlorosis increased as the time between clipping and inoculation increased up to 128 h. Intact leaves are apparently not infected by *C. lunata* (12). Brown et al. (3) inoculated *C. geniculata* and *C. lunata* onto Kentucky bluegrass, creeping red fescue, and creeping bentgrass at non-stress inducing temperatures of 20 to 24°C. They found no visible evidence of disease development or pathogenicity. Pratt (14) found that *C. lunata* and *C. geniculata*
were the least virulent when inoculated on common bermudagrass (*C. dactylon*) at 25°C; in some cases, disease severity was not significantly higher than in the control. In Pratt’s study (14), *B. cynodontis* and *B. spicifera* were more similar to *Exserohilum rostratum* in disease severity. However, the *Bipolaris* spp. were infrequently isolated from diseased field sites (whether severe, moderate, or low levels of disease) compared to either *E. rostratum* or the two *Curvularia* spp. In 2001, Pratt (15) reported that when common bermudagrass was inoculated with *B. hawaiiensis* at 25°C under plant-growth lights, a pathogenic response of chlorosis and necrotic lesions was obtained.

In the current study, *B. cynodontis* was pathogenic to the hybrid bermudagrass cultivars FloraDwarf, Tifdwarf, and TifEagle at both 20 and 30°C. Symptoms included leaf tip necrosis and many small necrotic leaf lesions on juvenile and mature tissue. Mean disease ratings were above four, indicating significant leaf tip dieback and leaf spotting. Unlike with the three senectopathic species, disease ratings were significantly greater when plants inoculated with *B. cynodontis* were incubated at 20°C than at 30°C. Leaf lesions formed quickly on all ages of tissue inoculated with *B. cynodontis*, usually within 24 h. These lesions were dark brown in color and did not continue to expand after formation. Bipolaris leaf spot caused by *B. cynodontis* is considered to be an important disease in many areas and causes significant leaf blighting in cool wet weather and may cause extensive damage to crowns, roots, and stolons (4,17).

Foliar inoculation of FloraDwarf, Tifdwarf, and TifEagle with *C. geniculata* and *C. lunata* under non-stress conditions at both 20 and 30°C failed to reproduce decline symptoms that have been previously reported to be caused by these fungi (17,19). However, the golf course symptoms are usually associated with predisposing plant stressors including high air temperatures (3,5,12,13). Unruh and Davis (20) reported canopy temperatures up to 142°F (61°C) during the hottest months of the ultradwarf bermudagrass monitoring program in 2000, and observed that bermudagrass cannot maintain good quality under such high temperatures. *Curvularia* spp. have been shown to be stronger saprophytic colonizers than *Bipolaris* spp., particularly at higher temperatures (7,8). Thus, *Curvularia* spp. associated with stressed and senescing tissue would likely be present under conditions of high temperature stress. Other environmental conditions that can potentially increase recovery of *Curvularia* spp. from stressed tissue include cloudy wet conditions (19) and previous infection by other pathogens, including *B. sorokiniana* (4,7,13). Smiley et al. (17) indicates that *Curvularia* spp. are weak pathogens that may be part of disease complexes. The current study supports conclusions of Muchovej and Couch (13) and Hodges and Madsen (7,8) that *Curvularia* spp. are efficient colonizers of senescing tissue (which may be induced by mowing or high temperatures), but do not cause disease symptoms in non-stressed turfgrass and thus should be considered as senectophytes, as defined by Couch (4). The results of experimental pathogenicity tests in this study contradict the conclusions drawn by Unruh and Davis (20), in a survey study of unhealthy golf course greens, that *Curvularia* spp. were pathogens of primary concern.

**Diagnosis and Management Implications**

*Curvularia* spp. are found colonizing the majority of turfgrass samples, including healthy tissue. *Curvularia geniculata* competes more aggressively for necrotic tissue than the pathogenic species, *B. sorokiniana* (8), including faster sporulation at 30°C and increased colonization of necrotic tissue. The ability of *Curvularia* spp. to colonize senescing tissue rapidly and to sporulate more readily than the pathogenic species present may lead to diagnosis of “Curvularia blight” to the exclusion of other leaf diseases. Subsequent application of fungicides in situations where the *Curvularia* spp. have already colonized senescent tissues would not likely be effective (4). Careful observation and association of symptoms (including chlorosis and individual leaf spots forming on juvenile and mature, but not senescing leaves) and identification of the fungal species (e.g., *B. cynodontis* vs. *B. hawaiiensis*) should result in more accurate diagnoses of pathogenic conditions in hybrid bermudagrasses. In the absence of a clearly pathogenic role for *Curvularia* spp. associated with
unhealthy, senescing turfgrass, diagnosticians and turfgrass managers should focus on determining the role of environmental stress in situations where turfgrass is declining and no other turfgrass pathogens are found to be primary causes.

In a golf course setting, chlorotic leaf tissue and the brown appearance of cut leaf tips colonized by senectopathic species, such as *C. lunata*, *C. geniculata*, and *B. hawaiiensis* could make the golf course green appear slightly mottled with chlorotic areas. Recovery from this condition would be rapid if conditions for bermudagrass growth are favorable. If conditions remain unfavorable for growth (high temperatures, high humidity, drought conditions, cloud cover, etc.), and significantly more senescent tissue is present than young tissue, thinning of the turfgrass canopy could occur. In this case, steps should be taken to either reduce stand thinning or increase leaf replacement (13). In high-end golf courses, tournament play, or other situations where even slight variation in appearance of the greens is not tolerable, the application of fungicides effective against *Curvularia* spp. may help to limit further development of mottling and discoloration. However, fungicide application alone will not speed recovery of the greens as only the growth of new, healthy green leaf tissue will eliminate the mottling and discoloration. Other cultural management steps should be taken as well, such as increasing the mowing height during high temperature or drought stress periods (20) or improving air circulation on the greens. If good air circulation is already established, syringing the affected areas (3,10) may help to reduce stress associated with high canopy temperatures. However, syringing in periods of high humidity may not be effective at cooling turfgrass canopies (10), and could create conditions for further growth and sporulation of fungi in already senescing tissue. In addition to these supplemental cultural measures, regular irrigation events should be timed to thoroughly wet the root zone, while avoiding frequent, shallow waterings to reduce stress on the turfgrass (4,10,17).

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**Literature Cited**