PLANT DISEASE

Diseases Caused by Dematiaceous Fungal Pathogens as Potential Limiting Factors for Production of Bermudagrass on Swine Effluent Application Sites

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ABSTRACT

Plant diseases that reduce the survival and productivity of forage crops on animal waste disposal sites may limit removal of waste-derived nutrients in harvested hay. However, no studies have documented the occurrence and importance of plant diseases on waste disposal sites in the southeastern USA. During 1998, symptoms of leaf, stem, crown, and root necrosis were observed in common bermudagrass [Cynodon dactylon (L.) Pers.] on three swine waste disposal sites in Mississippi. Species of Exserohilum, Bipolaris, and Curvularia grew from 82 to 100% of leaf and stem tissues from symptomatic plants, and six species were identified among 266 isolates. E. rostratum (Drechs.) Leonard & Suggs and B. spicifera (Rainier) Subramanian were most frequent in samples from a severely diseased stand, and C. lunata (Wakk.) Boedijn and C. geniculata (Tracy & Earle) Boedijn were most frequent from moderately and slightly diseased stands. In inoculation experiments, E. rostratum was most virulent and caused extensive necrosis of bermudagrass leaves; B. stenospora (Drechs.) Shoemaker, B. cynodontis (Marignoni) Shoemaker, and B. spicifera were intermediate in virulence; and C. lunata and C. geniculata were least virulent. When samples of healthy and diseased bermudagrass from a severely diseased site were compared for forage production over three harvests in the greenhouse, mean dry matter yields of diseased grass were 37 to 52% of healthy yields. Results indicate that dematiaceous fungal diseases may cause stand decline and yield reduction of bermudagrass on swine effluent application sites, and that E. rostratum and Bipolaris spp. are the most damaging pathogens encountered to date.

DISPOSAL OF WASTE MATERIALS from concentrated animal production facilities without contamination of soil and water with high levels of inorganic nutrients has become a major environmental challenge in some regions of the USA (Poore and Green, 1996; Sharpley et al., 1998; Sims, 1995; Sims and Wolf, 1994). Contamination of lakes, waterways, estuaries, and ground water with P and N as a result of surface runoff or leaching of nutrients from applied animal wastes (Andres, 1995; Eghball et al., 1996; Liu et al., 1997; Sharpley et al., 1998; Sims and Wolf, 1994; Vervoort et al., 1998) has been linked to toxic nitrate levels, eutrophication, destruction of aquatic habitat for fish and wildlife, creation of dead zones due to oxygen deprivation, and possibly outbreaks of diseases caused by human and animal parasites (Andres, 1995; Poore and Green, 1996; Sharpley et al., 1998; Sims and Wolf, 1994; USEPA, 1994; U.S. Senate Committee on Agric., Nutrition, and Forestry, 1997).

The principal method used for disposal of waste materials from concentrated animal production facilities is their application to croplands as fertilizers, and especially to forages that are grown for hay. Waste-derived nutrients are absorbed from soil by forage crops, incorporated into tissues, and removed from the site when forage is harvested for hay (Evers, 1996; Liu et al., 1997; Poore and Green, 1996).

In concentrated swine production systems in the southeastern USA, waste material is commonly sprayed onto pasture and forage crops in the form of a liquid effluent pumped from a holding lagoon (King et al., 1985; Liu et al., 1997). The principal forages are warm-season grasses including bermudagrass (Liu et al., 1997; Poore and Green, 1996); most effluent applications are performed by overhead spraying during summer months when these forages are actively growing (King et al., 1985). Cool-season grasses also may be grown on waste-application sites to augment nutrient removal during winter months (Phillips and Simpson, 1995).

A fundamental requirement for effective removal of excess nutrients from animal waste application sites is that grass crops must have the capacity to respond to nutrient applications with satisfactory growth and hay production. Diseases that significantly reduce growth of forage grasses in response to applied nutrients could potentially impede the effectiveness of hay-based systems for environmentally sound animal waste disposal. In bermudagrass stands to which swine effluent is applied, diseases caused by species of Exserohilum, Bipolaris, Drechslera, and Curvularia may have the potential to cause such problems. The first three of these genera were previously included within Helminthosporium (Alcorn, 1983). Approximately 12 species of the four genera are reported to cause diseases in bermudagrass (Couch, 1995; Smiley et al., 1992). Several are considered major pathogens that can infect leaves, stems, stolons, crowns, and roots (Couch, 1995; Gudauskas, 1962; Smiley et al., 1992) and cause decline and loss of entire stands (Smiley et al., 1992). Most studies of these diseases have involved bermudagrass grown for turf rather than forage (Gudauskas, 1962), and the diseases have not previously been recognized as limiting factors for production of bermudagrass hay on animal waste disposal sites in the southeastern USA.

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Abbreviation: ANOVA, analysis of variance.
During 1998, symptoms characteristic of diseases caused by dematiaceous fungal pathogens were observed on common bermudagrass at three locations in Mississippi where swine effluent was being applied. This study was undertaken to determine the etiology of these diseases, to compare the virulence of pathogens, and to estimate potential losses in forage production caused by diseases where symptoms were most severe.

MATERIALS AND METHODS

Isolation and Identification of Pathogens

Samples of stems, crowns, and roots of bermudagrass with symptoms of disease were collected from sites on three commercial swine-production farms in north central Mississippi where effluent was applied by overhead irrigation. Site 1 was on an Ora loam (fine-loamy, siliceous, semiactive, thermic Typic Fragiudult) that had received effluent for 2 yr. Samples were collected at Site 1 on 17 Sept. 1998 and stored at 5°C in sealed plastic bags with moisture for 0 to 4 d prior to assay. Site 2 was on a Brooksville silty clay (fine, smectic, thermic Aquic Chromudert) that had received effluent for 6 yr. Samples were collected at Site 2 on 6 Oct. 1998 and stored at 10°C for 2 d prior to assay. Site 3 was on an Atwood silt loam (fine-silty, mixed, thermic Typic Paleudalf) that had received effluent for 2 yr. Samples were collected at Site 3 on 2 Oct. 1998 and stored at 10°C for 10 d prior to assay.

Assays for the presence of dematiaceous fungal pathogens and isolations were attempted from 100 symptomatic stems from Site 1, 100 symptomatic leaves from different stems from Site 2, and 25 stems and 50 leaves from Site 3. Isolations were preferentially attempted from symptomatic stems when these were present to reduce contamination by saprophytes and to maximize chances for isolating the most virulent fungal pathogens. Sections (2.5-4.0 cm long) of stems with lesions were washed for 30 min in running tap water, dipped in an aqueous solution of ethanol (700 g/kg) for 10 s, swirled in a 20% (v/v) commercial bleach solution for 30 s, rinsed in distilled water, blotted on filter paper, and incubated on water agar (2 g agar/100 mL water) at room temperature. Mycelium or spores from colonies of potential dematiaceous fungal pathogens that developed from stems after incubation for 2 to 8 d were transferred to Bacto cornmeal agar (Difco Labs., Detroit) with a sterile needle. Sections (~2.5 cm) of symptomatic leaf tissue with borders of chlorotic or necrotic lesions were similarly washed, dipped in an aqueous solution of ethanol (700 g/kg) for 10 s, rinsed, blotted, and incubated on water agar. Spores of potential pathogens were transferred from areas of clean sporulation on leaves or colonies to cornmeal agar after 1 to 5 d. Isolates were identified according to standards in monographs (Alcorn, 1983; Couch, 1995; Smiley et al., 1992) and original species descriptions.

Evaluation of Pathogenicity

Pathogenicity was evaluated by spraying spores of pathogens onto leaves and stems of common bermudagrass after concentrations were adjusted to equivalent levels. To produce spores for inoculation experiments, isolates were grown on a sterile mixture of wheat and oat grain (Pratt, 1992). Flasks (250 mL capacity) containing 52 g wheat grain, 22 g oat, and 100 mL distilled water were autoclaved, inoculated with agar blocks from colonies, and incubated for 19 to 35 d at room temperature. Infested grain then was spread in thin layers, air-dried for 2 d at 23°C, and stored in sealed plastic bags at 10°C for up to four months prior to use. Portions of dry grain infested with three randomly selected isolates (where available) of each species were mixed (25 g total) and comminuted in a blender (Osterizer, Galaxy model, dual-range, Sunbeam Corp., Boca Raton, FL) for 30 s. Grain then was dusted onto plates of water agar (0.4 g/plate) and incubated for 7 d on the lab bench. During this time, numerous spores were produced on colonies that developed from particles of infested grain. Spores were harvested by adding 20 mL of a dilute (20 g/L) nutrient adhesive solution (Pelgel, Liphatech, Milwaukee, WI) to each plate, scraping colonies with a microspatula, and filtering through four-layer cheesecloth. Spores then were diluted to a concentration of 2 × 10^6 spores/mL based on six haemacytometer counts.

Seed of common bermudagrass were sown in 240-mL (8-oz) styrofoam cups (0.04 g/cup) containing a commercial peat-based potting mixture and grown for 7 to 8 wk in the greenhouse. Plants were fertilized with 15-30-15 fertilizer (20 mL/cup) at weekly intervals beginning 3 wk after planting. For inoculation experiments, each cup with seedlings was placed inside a plastic cup surrounded by a plastic bag, and water was added to the bag. Plants in five cups were sprayed evenly to runoff with 100 mL spore suspension. Control plants were sprayed with the adhesive solution only. Bags then were pulled up and sealed to create a humidity chamber around each cup. Five replicate cups of each treatment were arranged in randomized complete blocks on a bench under fluorescent growth lights on a 12-h photoperiod at 25°C. After 3 d, bags were removed and the percentage of foliage in each pot with tissue completely chlorotic or necrotic was estimated visually. Similar estimates were made again at 10 d after inoculation, after which plants were removed to the greenhouse. Estimates of symptom severity were compared by use of the LSD test at P ≤ 0.05 after treatment differences were declared significant by analysis of variance (ANOVA) and after arcsin transformation of the square root of the data. At 21 to 28 d after inoculation, samples of plants were removed from cups, washed, and examined for symptoms of infection in stems, crowns, and roots. Symptomatic tissues were disinfested and incubated on water agar to observe for fungal sporulation.

Yield Loss Estimates for Diseased Bermudagrass

Samples of healthy-appearing and diseased bermudagrass turf, approximately 10 cm diam. and 15 cm deep, were cut from the site with the most severe symptoms in October and trimmed to fit into 10-cm-diam. clay pots. Samples were arranged in two randomized complete-block experiments, with 15 replicates in each, clipped to a uniform height (~2 cm) initially, and maintained in greenhouses for four months at 18 to 27°C with daily watering but without fertilization. Supplementary overhead light was supplied from high-pressure sodium lamps on a 12-h photoperiod. Foliage was clipped from each pot in three successive harvests at 4- to 10-wk intervals, when new growth in the most vigorous pots was approximately 20 to 40 cm tall, and dry matter yields were determined following drying at 66°C for 3 d. Results were compared separately at each harvest date by ANOVA.

RESULTS

Symptoms of Disease and Isolation of Pathogens

Disease symptoms were most severe at Site 1, where portions of the stand were stunted, thinned, or dead.
Necrotic lesions were present on leaf blades and sheaths that extended basally from tips, and frequently all leaf tissue on stems was dead. Dark brown to purple-black lesions developed in stems at nodes and progressed basally and distally into internodal tissue. Dark brown lesions also were present within tissue of stolons, crowns, and upper roots. Frequently entire plants and runners were killed. Areas with severe disease had a withered, grey or frosted appearance. Nearly all plants in some of these areas appeared dead from a distance, but closer inspection revealed that some surviving plants with green leaves and stems were always present among dead plants. Symptoms occurred in oblong, circular, or semi-circular patches up to 0.2 ha in size, but these often intergraded or merged to cover much larger areas. Borders between diseased and healthy-appearing portions of the stand were usually diffuse and indistinct.

At Site 2, bermudagrass occurred in patches within a volunteer stand. Disease symptoms were present in all bermudagrass plants at this site, but these were largely restricted to leaf blades and sheaths. Leaf tissue was discolored light tan to yellow, but underlying stem tissue evidenced few lesions, and new green leaves often emerged at tips of stems even when all lower leaves were chlorotic or necrotic. Stolons, crowns, and roots of plants at this site were usually nonsymptomatic.

Bermudagrass at Site 3 was largely green, vigorous, and healthy-appearing, but symptoms similar to those at both Sites 1 and 2 were present in small, individual patches (30–60 cm diam.) scattered in the stand.

Symptoms of zonate leaf spot [Drechslera gigantea (Heald & F.A. Wolf) Ito] (Couch, 1995) also were observed in bermudagrass at all sites, and the identity of the causal organism was confirmed by isolations. Although symptoms were conspicuous and present throughout stands, they occurred at low frequencies (<5% of stems) and did not appear likely to have caused significant losses in forage production.

Colonies or sporulation by genera of dematiaceous fungal pathogens were observed from 95% of assayed stems from Site 1, 82% of leaves from Site 2, and 100% of stems and leaves from Site 3. Identities and numbers of species isolated from leaf or stem tissue from each site are given in Table 1. Numbers of isolates corresponded closely but not exactly with numbers of tissue pieces that assayed positive for dematiaceous fungal pathogens, because a single transfer of mycelium or spores attempted from most positive stems and leaves. However, from some tissue pieces, two transfers were attempted from colonies that appeared to differ morphologically. From others, transfers were not accomplished successfully due to overgrowth by contaminating saprophytic fungi and bacteria.

At Site 1 with severe disease symptoms, E. rostratum and B. spicifera were isolated most frequently and together composed 96% of all isolates from stems (Table 1). These pathogens also were isolated from crowns and roots of symptomatic bermudagrass (data not shown). Curvularia lunata composed only 3% of isolates from Site 1. In contrast, at Sites 2 and 3, with less severe disease, C. lunata and C. geniculata together composed

| Table 1. Identity and number of dematiaceous fungal pathogens isolated from symptomatic bermudagrass stems and leaves from three swine-effluent application sites in Mississippi in 1998.† |
|---------------------------------|--------|--------|--------|--------|
| Species                        | Site 1  | Site 2  | Site 3  |
|                                | Stems  | Leaves | Stems  | Leaves |
| Exserohilum rostratum          | 81     | 2      | 2      |
| Bipolaris spicifera            | 15     | 1      | 3      |
| B. cynodontis                  | 1      | 3      | 1      |
| B. stenospila                  | 3      | 1      | 11     | 18     |
| Curvularia lunata              | 19     | 8      | 22     |
| C. geniculata                  | 19     | 8      | 22     |
| Site total                     | 100    | 100    | 20     | 46     |

† Isolates were obtained by transfer of mycelium or spores from colonies of dematiaceous fungal pathogens that developed on water agar from 100 symptomatic stem sections from Site 1, 100 symptomatic leaf sections from Site 2, and 25 stem and 50 leaf sections from Site 3. One or two colonies were transferred per tissue piece except when growth of contaminants was prohibitive. The three sites were located on commercial swine-production farms in north-central Mississippi.

≥87% of isolates, whereas E. rostratum and B. spicifera seldom were isolated. B. cynodontis and B. stenospila also were isolated at only low frequencies from all sites (Table 1).

### Comparative Virulence of Fungal Pathogens

All species incited symptoms of flecking, chlorosis, and necrosis in bermudagrass foliage following spore inoculations, but severity of symptoms differed among species. Symptoms were most clear immediately after removal of plants from plastic bags at 3 d; subsequently, much of the infected tissue became shriveled and difficult to observe. Leaves infected by Curvularia spp. were yellow to light brown, and leaves infected by Bipolaris and Exserohilum were a slightly darker brown. Symptoms were always most severe on oldest leaves and leaf sheaths, where necrotic lesions expanded longitudinally and transversely from infection points and coalesced to girdle and kill leaf blades. On progressively younger leaf tissue, lesions were more restricted and eventually reduced to necrotic flecks. Often no symptoms developed on the youngest leaves. Symptoms caused by the most virulent species extended furthest upward on progressively younger leaves.

In both inoculation experiments, E. rostratum caused the most severe symptoms at both 3 and 10 d after inoculation (Table 2). The general progression of symptom severity for remaining species was B. stenospila > B. cynodontis > B. spicifera > C. lunata and C. geniculata. Percentages of tissues estimated to be symptomatic were variable from 3 to 10 d after inoculation depending on increased lesion development and death of infected leaves, and increased development of new leaves from stem tips. All species were consistently reisolated from sporulating colonies that developed from symptomatic, inoculated leaves that were disinfested and incubated on water agar at 3 to 10 d after inoculation.

At 4 wk after inoculation of foliage, many plants in all treatments exhibited necrosis of lower leaf sheaths that extended to the bases of stems. Few lesions were
present in upper stems even when they were surrounded entirely by necrotic leaf sheaths. However, necrosis frequently extended from basal leaf sheaths into crowns and upper roots. This caused discoloration, rotting, and death of roots, portions of crowns, and some whole plants. Such symptoms were most common and severe among plants inoculated with *E. rostratum* and *B. spicifera*. These species behaved as the most aggressive crown and root pathogens and were reisolated consistently (>50%) from crowns and roots of inoculated plants and also frequently from plants of other treatments. This spread of *E. rostratum* and *B. spicifera* in the growth room or greenhouse precluded evaluations of crown and root symptoms by treatment. *Curvularia lunata* was reisolated occasionally from crowns and more frequently from upper roots; some spread of *C. lunata* to plants in other treatments also occurred in both experiments. *Bipolaris cynodontis*, *B. stenospila*, and *C. geniculata* were reisolated occasionally from crowns of plants onto which they had been inoculated but never from plants of other treatments.

### Estimates of Yield Loss Due to Disease

Dry matter yields of samples of healthy and diseased bermudagrass from Site 1 (most severe disease symptoms), which were obtained from three successive harvests of two experiments in the greenhouse, are presented in Table 3. At all harvests within both experiments, mean yields from diseased samples were 37 to 52% of mean yields from healthy samples, and these differed significantly at $P \leq 0.01$ at each harvest.

### DISCUSSION

A fundamental requirement for proper functioning of a swine waste disposal system on bermudagrass is that the grass must have the capability to respond to effluent applications with satisfactory growth and production of harvestable forage. Observations and results of this study indicate that diseases caused by dematieaceous fungal pathogens may impede this process by reducing the vigor, growth, and survival of bermudagrass to which effluent is applied. Presumably nutrient removal is reduced in situations where disease symptoms are severe because less forage is produced and harvested despite effluent applications; unabsorbed nutrients then must either remain in soil, volatilize, or move into surface or ground water as contaminants (Liu et al., 1997; Poore and Green, 1996). Applying waste materials to grass crops with a low capacity for forage production due to disease might be comparable to long-term fertilization or overfertilization of a healthy crop, both of which have been shown to cause buildup of N and P in soil (Eghball et al., 1996; King et al., 1985; Kingery et al., 1994; Liu et al., 1997; Poore and Green, 1996; Vervoort et al., 1998).

### Table 2. Severity of symptoms induced by six species of dematieaceous fungal pathogens in common bermudagrass following spore inoculations.†

<table>
<thead>
<tr>
<th>Species</th>
<th>Mean percentage of leaves and stems chlorotic and necrotic at 3 and 10 d after inoculation‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experiment 1</td>
</tr>
<tr>
<td></td>
<td>3 d</td>
</tr>
<tr>
<td><em>Exserohilum rostratum</em></td>
<td>80a§</td>
</tr>
<tr>
<td><em>Bipolaris stenospila</em></td>
<td>42b</td>
</tr>
<tr>
<td><em>B. cynodontis</em></td>
<td>33c</td>
</tr>
<tr>
<td><em>B. spicifera</em></td>
<td>30c</td>
</tr>
<tr>
<td><em>Curvularia lunata</em></td>
<td>15d</td>
</tr>
<tr>
<td><em>C. geniculata</em></td>
<td>12d</td>
</tr>
<tr>
<td>Control</td>
<td>7e</td>
</tr>
</tbody>
</table>

† Spores of all species were adjusted to $2 \times 10^{5}$/mL and sprayed onto leaves and stems of bermudagrass grown in a greenhouse. § Within columns, means followed by the same letter are not significantly different according to LSD (0.05).

### Table 3. Dry-matter yields of samples of healthy-appearing and diseased bermudagrass from a swine-effluent application site in north-central Mississippi following growth in the greenhouse.†

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Harvest</th>
<th>Mean dry-matter yield (g/pot)‡</th>
<th>Diseased/healthy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.81</td>
<td>2.16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.64</td>
<td>1.55</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.34</td>
<td>0.74</td>
</tr>
</tbody>
</table>

† Samples collected from Site 1 were potted, clipped to a uniform height, and maintained in greenhouses for 4 to 6 months in 1998±99. Forage was harvested from all pots on 5-10-wk intervals after growth to 20 to 40 cm tall in the most vigorous pots. ‡ Values are means of 15 pots per treatment. At each harvest, means differed significantly at $P \leq 0.01$ as determined by ANOVA.
ing inoculation with the most virulent pathogens. All pathogens then were reisolated from symptomatic tissues. These results are compatible with previous descriptions of the nature and severity of disease symptoms induced by these dematiaceous fungi (Couch, 1995; Smiley et al., 1992). The results also indicate that there appears to be no need at present to look for alternative or additional causes for the disease symptoms originally observed in the field.

Differences in the nature and severity of symptoms observed at the three sites corresponded well with frequencies of isolation of specific pathogens from symptomatic tissue, and with differences in virulence of the pathogens as manifested in inoculation experiments. These correlations further indicate that the pathogens were the primary causal agents of the observed disease symptoms. In a field where symptoms were most severe, Bipolaris spicifera was the principal pathogen isolated from stem lesions, and this species also was consistently the most virulent of all pathogens tested. B. spicifera also was isolated more frequently from the field with severe symptoms than at other sites, and this species was intermediate in virulence on inoculated plants. Couch (1995) noted that simultaneous infection by these and other species occurs commonly on bermudagrass.

In contrast, at the two sites where symptoms were less severe and largely restricted to leaves, Curvularia lunata and C. geniculata were the species most frequently isolated. Exserohilum rostratum, B. spicifera, and the other Bipolaris spp. were infrequently detected there. Both Curvularia spp. incited less severe symptoms than Exserohilum and Bipolaris spp. in controlled inoculation experiments. Therefore, data on the frequency and virulence of Curvularia spp. also corresponded well with observations of symptom severity in the field.

Bipolaris cynodontis and B. stenospila ranked close to E. rostratum in virulence on bermudagrass, but these species were isolated infrequently from symptomatic tissues at all sites. Reasons for their restricted distribution, either seasonal or geographical or pathological, are not known, but it appears that either species could incite major losses wherever they might become widespread.

Although C. lunata and C. geniculata were the least virulent pathogens in comparative inoculation experiments in this study, their potential for inciting damage or reducing yields of bermudagrass in the field should not be disregarded on the basis of these results. Couch (1995) considers Curvularia spp. to be pathogens primarily of senescent stands or tissues under environmental stress, and Smiley et al. (1992) consider high temperature stress (≥30°C) an important predisposing factor for pathogenesis. Therefore, both the age of plants and conditions under which they were grown and inoculated in this study may have minimized symptom development by C. lunata and C. geniculata in comparison to what they might induce in the field.

Drechslera gigantea was conspicuous on bermudagrass at all sites, but symptoms were largely restricted to noncoalescing leafspots, and overall incidences were low. These observations suggest that zonate leaf spot may not be as important a limiting factor for production of bermudagrass forage on swine waste disposal sites as are diseases incited by some of the other dematiaceous fungal pathogens.

A few discrepancies are apparent between results of this study and previous reports on the pathogenicity of dematiaceous fungi on bermudagrass and virulence of species. Bipolaris spicifera was reported to be incapable of penetrating uninjured plant surfaces of bermudagrass (Gudauskas, 1962), but the present results clearly indicate otherwise. Couch (1995) stated that B. stenospila was more damaging on bermudagrass than E. rostratum (D. rostrata), but results of these experiments indicate the opposite to be true (although only one isolate of B. stenospila was compared). Possible reasons for such discrepancies are that most previous reports only evaluated the virulence of single species, and that previous studies utilized different isolates, inoculation procedures, and plant growth conditions.

Symptoms present in crowns and roots of inoculated plants after 4 wk could not be assigned to specific pathogens because of the spread of E. rostratum, B. spicifera, and less frequently C. lunata, to pots of other treatments. However, these observations still suggest that E. rostratum and B. spicifera are the most aggressive crown and root pathogens. Curvularia lunata was isolated only occasionally from crowns but more frequently from upper roots; this species also may be important as a root pathogen as indicated previously (Smiley et al., 1992). Further experiments with crown and root inoculations under conditions that are more controlled, and which limit the spread of the most aggressive pathogens to other treatments, are necessary to evaluate further the potential of these six pathogens to parasitize crowns and roots of bermudagrass.

Relationships of the occurrence and severity of diseases caused by dematiaceous fungal pathogens to the actual applications of swine effluent on bermudagrass are not clear. At the site with the most severe disease symptoms, these were present both within and beyond the edge of the effluent spray pattern. Some plant diseases are more severe with high N and P fertility (Bell, 1989; Huber and Watson, 1974), but exceptions to both situations are known (Huber and McCoy-Buis, 1993; Huber, 1989). In a study of the effects of soil fertility on infection of bermudagrass by B. cynodontis, Matocha and Smith (1980) found that increased potassium fertilization reduced severity of leaf blight.

Control of diseases incited by dematiaceous fungal pathogens of bermudagrass in swine effluent application systems, or other systems where animal wastes are applied, may ultimately require use of existing resistant cultivars, if available, or the breeding of new cultivars for this purpose. Several cultivars of forage bermudagrass are reported to differ in resistance and susceptibility to dematiaceous fungal pathogens, but specific diseases or pathogens often are not indicated (Taliaferro and Richardson, 1980a and 1980b). The fact that in this study, some surviving plants were observed in all samples of common bermudagrass, even in areas with severe disease, suggests that some individual plants may be more resistant than others. Possibly such plants could
be selected for the breeding of future resistant cultivars. However, the multiplicity of dematiaceous fungal pathogens that can cause diseases of bermudagrass suggests that effective use of host resistance may require either site-specific diagnosis of species of pathogens present, or the breeding of multiple-pathogen-resistant bermudagrass cultivars.

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REFERENCES