Weed Hosts of the Sugarcane Root Rot Pathogen, *Pythium arrhenomanes*

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ABSTRACT

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Weeds in the Poaceae and Cyperaceae families prevalent in sugarcane fields were evaluated as potential hosts for the root rot pathogen, *Pythium arrhenomanes*. In greenhouse studies, bermudagrass, broadleaf signalgrass, browntop panicum, barnyardgrass, large crabgrass, goosegrass, itchgrass, johnsongrass, Italian ryegrass, and purple nutsedge became infected when grown in steam-treated soil infested with *P. arrhenomanes*. However, the extent of root colonization, symptom severity, and growth reductions varied among species. Symptom severity and root colonization by *P. arrhenomanes* were less when weeds were grown in sugarcane field soil in the greenhouse than when weeds were grown in *Pythium*-infested, steam-treated field soil. Levels of root colonization by *P. arrhenomanes* in both experiments were greatest for johnsongrass and itchgrass and lowest for browntop panicum, goosegrass, and Italian ryegrass. For weeds collected from sugarcane fields, frequencies for colonized plants were moderate to high, but the extent of root colonization by *P. arrhenomanes* was low for all except johnsongrass. The results indicate that weeds can serve as hosts for *P. arrhenomanes* and may play roles in the epidemiology of *Pythium* root rot on sugarcane.

Pythium arrhenomanes Drechs. is the causal agent of root rot on sugarcane (interspecific hybrids of *Saccharum* spp.) (4,7,10) and other Poaceae crops (11). However, knowledge concerning the epidemiology of *Pythium* root rot of sugarcane is limited. For example, the relative importance of different mechanisms by which *P. arrhenomanes* persists in soil is uncertain. The oospore, which results from meiosis, is a potential long-term survival structure for most species in the genus *Pythium*. However, *P. arrhenomanes* is difficult to isolate from soil (J. W. Hoy, unpublished). In culture, most oospores formed by *P. arrhenomanes* abort. However, successful oospore formation may be more common in natural substrates, such as infected sugarcane roots.

Colonization of roots of weed hosts could be another possible means of persistence and a source of inoculum, especially for the plant cane (first year) crop of sugarcane grown following a spring and summer fallow period. Both annual and perennial grasses are prevalent in sugarcane fields in Louisiana.

Weeds have been demonstrated to be alternative hosts for several plant pathogens (1-3,6,11,13). *P. arrhenomanes* was isolated from roots of grass species native to the north central plains of North America (11,13). The objective of this study was to evaluate weeds associated with sugarcane culture as possible hosts for *P. arrhenomanes*.

MATERIALS AND METHODS

The effects of *Pythium* root rot on plant growth, severity of root rot symptoms, and extent of root colonization by *P. arrhenomanes* were quantified for nine grasses and one sedge. In the greenhouse, growth of plants in steam-sterilized (steam-treated 24 h) field soil mixed with an equal volume of sterile sand was compared with growth of plants in steam-treated field soil:sand mix infested with *P. arrhenomanes* (pathogenicity test) or in nonsterile field soil mixed 1:1 with sterile sand. In other studies, *Pythium* spp. were isolated from roots of weeds collected from commercial sugarcane fields.

Greenhouse pathogenicity tests.

Pathogenicity tests were conducted during spring 1993 and 1995. Seed of barnyardgrass (*Echinochloa crus-galli*), bermudagrass (*Cynodon dactylon*), browntop panicum (*Panicum fasciculatum*), broadleaf signalgrass (*Brachiaria platyphylla*), large crabgrass (*Digitaria sanguinalis*), goosegrass (*Eleusine indica*), itchgrass (*Rottboellia cochinchinensis*), johnsongrass (*Sorghum halepense*), Italian ryegrass (*Lolium multiflorum*), and purple nutsedge (*Cyperus rotundus*) were germinated in sterile sand:silt loam soil mixture (1:1, vol/vol).

When the first true leaves began to emerge, seedlings were transplanted to 7.5-cm-diameter sterilized clay pots containing either steam-treated field soil:sand mix (SFS) or SFS infested with *P. arrhenomanes* inoculum.

Inoculum of *P. arrhenomanes* was prepared by a modification of a method described previously (14) in which 450 cm³ of vermiculite, 20 cm³ of whole oat seeds, and 350 ml of V8 juice mixture (200 ml of V8 vegetable cocktail juice, 800 ml of water, and 2 g of CaCO₃) were autoclaved in a 900-ml canning jar for 2 consecutive days. Each jar was then inoculated with eight agar plugs with actively growing mycelium of *P. arrhenomanes*, and the fungus was allowed to colonize the substrate for 2 weeks at room temperature. The inoculum was then placed in cheesecloth, rinsed thoroughly with water, and mixed with steam-treated soil:sand mixture at a rate of 20 cm³ per 1,000 cm³ of soil:sand mixture. Pots were arranged on a greenhouse bench in a completely randomized design with six replicates. Plants were grown for 8 weeks in the greenhouse at temperatures ranging between 22 and 28°C. A 20-20-20 (N-P-K) water-soluble fertilizer (3.95 g/liter) was applied at 10- to 14-day intervals at a rate of 25 ml per pot.

Plant growth and root rot were evaluated after 8 weeks. All plants were removed from pots, and root systems were gently washed free of soil. Total number of shoots and/or stolons, maximum height or length of shoots and/or stolons, number of primary roots, and total root system length (measured from the crown to the longest root tip) were determined. In addition, the root system of each plant was evaluated by subjective visual ratings for the amount of lateral roots and root system discoloration caused by *Pythium* root rot. Visual ratings were made on a scale of 1 to 4 in which 1 = healthy, no discoloration or reduction of lateral roots compared with plants grown in steam-treated soil; 1.5 = very mild disease, up to 10% of the root system discolored or reduction in lateral roots; 2 = mild disease, up to 25% of the root system discolored with symptoms or lateral root system reduction; 2.5 = moderate disease, >25 to 50% of the root system discolored with symptoms or reduction in lateral roots; 3 = severe disease, >50 to 75% of the root system discolored or lateral root system reduction; 3.5 = very severe disease, 75 to 90% of the root system discolored or reduction in lateral roots; and 4 = dead roots, >90% of the

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root system discolored and no lateral roots due to root rot.

The percent root length colonized by *Pythium* was estimated by plating six randomly selected 5-cm lengths of primary root with attached laterals per plant (180 cm per weed species). The root segments

from each plant were placed in a 125-ml Erlenmeyer flask with 50 ml of sterile, deionized water on a shaker (75 rpm) for 2 h, and then blotted dry with paper towels. Root segments were placed in a 9-cm-diameter petri dish (three per plate), and PVPS-modified *Pythium*-selective medium

(9) (10 g each of corn meal agar and agar autoclaved in 1 liter of distilled water amended after cooling to 45°C with 300 mg of vancomycin dissolved in 10 ml of sterile water, 15 mg of pentachloronitrobenzene dissolved in 95% EtOH, 0.4 ml of pimaricin [10 mg a.i.], and 300 mg of spectinomycin dissolved in 10 ml of sterile water) was poured over roots until they were immersed. Plates were then incubated at room temperature.

The length of root segments from which *Pythium* mycelium was growing into the media was measured from 24 to 32 h after plating. An average of six isolates from each plate were transferred to V8 medium (200 ml of V8 vegetable juice cocktail, 800 ml of water, and 15 g of agar, pH 4.8, amended with 300 µg of penicillin) plates. After 24 to 48 h, six to eight agar plugs, 3 mm in diameter, containing actively growing *Pythium* mycelium, were transferred from each isolate into a 6-cm-diameter petri dish and flooded with 5 ml of filter-sterilized soil extract. After 2 to 3 days incubation at room temperature, each isolate was examined microscopically, and *P. arrhenomanes* isolates were identified based on the morphological characteristics of reproductive structures (12).

Field soil greenhouse experiments.

The same grass species used in the pathogenicity tests were grown in the greenhouse in Commerce silt loam soil collected from a sugarcane field at the St. Gabriel Research Station of the Louisiana Agricultural Experiment Station in Iberville Parish during spring 1994 and 1995. Soil was sieved through a 1-cm-mesh screen and mixed with sterile sand to a final soil:sand ratio of 2:1 (vol/vol). Half of the field soil:sand mixture was left unchanged (FS), and the other half was steam-treated (SFS) for 24 h. Grass seeds were germinated and grown in sterile soil:sand mixture and then transplanted, as described for the pathogenicity tests. Plant growth, root rot severity, and root colonization by *P. arrhenomanes* were determined as described previously.

Root colonization by *P. arrhenomanes* in field-collected grass weeds. Root colonization by *P. arrhenomanes* was determined for grass weeds collected from multiple sugarcane fields at the St. Gabriel Research Station during October 1994 and from St. John the Baptist Parish during May 1995. Roots of barnyardgrass, bermudagrass, broadleaf signalgrass, browntop panicum, large crabgrass, goosegrass, johnsongrass, and vaseygrass (*Paspalum urvillei*) were collected, and the extent of root colonization by *P. arrhenomanes* under natural field conditions was determined.

Twelve to 20 plants of each species were collected. Roots were gently washed free of soil and blotted dry with paper towels. The percent root length colonized by *P. arrhenomanes* was estimated by plating six

Table 1. Effects of *Pythium arrhenomanes* on root and shoot growth of 10 weed species

Weed	Soil treatment ^a	Shoot and root growth parameters ^b			
		Shoot number	Shoot length	Primary root number	Root system length
Bermudagrass	SFS	10.4	68.4	14.9	24.4
	SFS+Pa	3.9*	26.4*	6.4*	11.0*
Broadleaf	SFS	9.1	34.8	20.6	23.1
signalgrass	SFS+Pa	1.9*	18.0*	7.9*	8.1*
Browntop	SFS	3.8	55.0	17.5	19.3
panicum	SFS+Pa	1.0*	47.0	10.1*	15.8
Barnyardgrass	SFS	9.8	31.1	21.5	18.0
	SFS+Pa	1.9*	18.8*	14.6*	12.0*
Large crabgrass	SFS	6.8	33.8	15.9	21.4
	SFS+Pa	1.7*	33.0	7.3*	9.1*
Goosegrass	SFS	6.1	34.9	23.5	19.7
	SFS+Pa	2.0*	35.2	13.7*	12.2*
Itchgrass	SFS	2.6	35.9	5.8	18.6
	SFS+Pa	1.4*	23.0*	2.9*	10.4*
Johnsongrass	SFS	5.8	68.6	26.7	31.9
	SFS+Pa	1.7*	38.6*	7.9*	18.2*
Italian ryegrass	SFS	11.0	43.8	7.4	17.3
	SFS+Pa	4.4*	36.4*	6.1*	14.7*
Purple nutsedge	SFS	1.0	18.0	8.6	11.6
	SFS+Pa	1.0	17.0	7.6	10.2

^a Soil treatments included steam-treated field soil mixed 1:1 with sterile sand (SFS) and SFS infested with *P. arrhenomanes* inoculum (SFS+Pa).

^b Each value represents a mean of 12 total replicates from two experiments. For individual weeds, SFS+Pa means followed by * within a column are different ($P > 0.95$) from the corresponding SFS mean.

Table 2. Effects of *Pythium arrhenomanes* on root disease variables for 10 weed species

Weed	Soil treatment ^a	Root disease variables ^b		
		Lateral root reduction (%)	Root system discoloration (%)	Root colonization by <i>P. arrhenomanes</i> (%)
Bermudagrass	SFS	0.0	0.0	0.0
	SFS+Pa	29.9*	22.0*	50.2*
Broadleaf	SFS	0.0	0.0	0.0
signalgrass	SFS+Pa	34.5*	22.1*	50.2*
Browntop	SFS	0.0	0.0	0.0
panicum	SFS+Pa	25.0*	25.0*	38.8*
Barnyardgrass	SFS	0.0	0.0	0.0
	SFS+Pa	6.5	6.5	66.8*
Large crabgrass	SFS	0.0	0.0	0.0
	SFS+Pa	41.7*	43.7*	65.3*
Goosegrass	SFS	0.0	0.0	0.0
	SFS+Pa	16.9*	21.9*	36.7
Itchgrass	SFS	0.0	0.0	0.0
	SFS+Pa	36.5*	33.5*	81.7*
Johnsongrass	SFS	0.0	0.0	0.0
	SFS+Pa	50.7*	50.0*	85.4*
Italian ryegrass	SFS	0.0	0.0	0.0
	SFS+Pa	25.1*	0.0	31.5*
Purple nutsedge	SFS	0.0	0.0	0.0
	SFS+Pa	0.0	0.0	43.2*
LSD (0.05) ^c		10.3	7.7	8.7

^a Soil treatments included steam-treated field soil mixed 1:1 with sterile sand (SFS) and SFS infested with *P. arrhenomanes* inoculum.

^b Each value represents a mean of 12 total replicates from two experiments. For individual weeds, SFS+Pa means followed by * within a column are different ($P > 0.95$) from the corresponding SFS mean.

^c Means for different weeds growing in SFS+Pa (but not SFS) were compared within root disease variables using Fisher's Protected Least Significant Difference.

randomly selected 5-cm lengths of root per plant. The same isolation and species identification methods were used as described for the greenhouse experiments.

For all studies, visual ratings on root disease variables were converted to mid-point percentage values of the appropriate interval, and percentages for root length colonized by *P. arrhenomanes* were arcsine transformed before statistical analysis. Data were subjected to analysis of variance for individual and combined experiments. The results from the greenhouse experiments were similar, so combined analyses are presented. Differences among treatment means were determined using Fisher's Protected Least Significant Difference (LSD) test at the 5% level of probability.

RESULTS

Pathogenicity tests. All the grasses and purple nutsedge became infected with *P. arrhenomanes*. The number of shoots or stolons per plant was reduced in soil infested with *P. arrhenomanes* for each grass species compared with plants grown in steam-treated soil (Table 1). The length of shoots or stolons also was lower for infected grass weeds, except brown top panicum, crabgrass, goosegrass, and purple nutsedge (Table 1). The number of primary roots of all weeds and the root system length of all except browntop panicum and purple nutsedge were reduced for infected plants (Table 1).

Lateral root systems were reduced by *P. arrhenomanes* for all weeds except barnyardgrass and nutsedge (Table 2). Root discoloration was not evident in barnyardgrass, Italian ryegrass, and purple nutsedge (Table 2). The other grasses exhibited mild to moderate symptom severity. The most severe symptoms were observed in johnsongrass and large crabgrass. The percentage of root length colonized by *P. arrhenomanes* ranged from 32 to 85% for weeds (Table 2). The level of colonization was greatest for johnsongrass and itchgrass (at least 82%), whereas colonization of Italian ryegrass roots was less than that for purple nutsedge.

Plant growth and root rot severity in field soil. Shoot and root growth of most grasses was less for plants grown in the greenhouse in field soil:sand mix compared with plants grown in steam-treated field soil:sand mix (Table 3). Shoot number and root system length were not reduced for goosegrass and Italian ryegrass grown in field soil. The amount of lateral roots was reduced for all weeds except broadleaf signalgrass (Table 4). Compared with plants grown in steam-treated field soil, little or no root discoloration was observed in bermudagrass, browntop panicum, large crabgrass, and Italian ryegrass grown in field soil (Table 4). Root disease symptoms in weeds were generally mild except in itchgrass and johnsongrass, where lateral root development was re-

duced 30 and 52%, respectively (Table 4). Severe root system discoloration was not observed for any weeds except johnsongrass (64%).

Root colonization by *P. arrhenomanes* ranged from 5 to 30% for the grass weeds grown in field soil (Table 4). As noted for lateral root reduction and root discoloration, johnsongrass and itchgrass exhibited

the most extensive root colonization by *P. arrhenomanes*. The percent root length colonized by *P. arrhenomanes* was relatively low for all weeds compared to values observed in the pathogenicity tests (Table 2). However, the percentages of root length colonized by total *Pythium* spp. were of similar magnitude to those observed in pathogenicity tests (Table 4).

Table 3. Root and shoot growth of nine weeds in sugarcane field soil in comparison with plants grown in steam-treated field soil

Weed	Soil treatment ^a	Shoot and root growth parameters ^b			
		Shoot number	Shoot length	Primary root number	Root system length
Bermudagrass	SFS	3.4	36.8	12.7	19.9
	FS	2.3*	28.5*	6.1*	12.1*
Broadleaf signalgrass	SFS	3.1	58.3	12.9	25.1
	FS	1.6*	31.8*	8.2*	13.9*
Browntop panicum	SFS	3.5	57.4	17.7	22.8
	FS	1.5*	28.3*	11.7*	11.3*
Barnyardgrass	SFS	3.7	27.3	14.9	16.4
	FS	1.9*	18.6*	8.5*	12.2*
Large crabgrass	SFS	3.0	53.8	14.0	18.1
	FS	1.7*	29.7*	8.2*	15.3*
Goosegrass	SFS	3.5	45.0	21.8	26.0
	FS	2.8	24.3*	10.2*	18.2
Itchgrass	SFS	1.0	58.3	7.4	16.8
	FS	1.0	26.5*	3.9*	10.9*
Johnsongrass	SFS	3.4	64.5	23.9	18.1
	FS	1.5*	39.1*	12.0*	12.3*
Italian ryegrass	SFS	4.0	36.2	8.4	9.3
	FS	3.0	24.9*	4.8*	7.6

^a Soil treatments included steam-treated field soil mixed 2:1 with sterile sand (SFS) and nonsterile field soil mixed with sterile sand (FS).

^b Each value represents a mean of 12 total replicates from two experiments. For individual weeds, FS means followed by * within a column are different ($P > 0.95$) from the corresponding SFS mean.

Table 4. Root disease variables of nine weeds grown in sugarcane field soil in comparison with plants grown in steam-treated field soil

Weed	Soil treatment ^a	Root disease variables ^b			
		Lateral root reduction (%)	Root system discoloration (%)	Root colonization ^c	
Bermudagrass	SFS	0.0	0.0	0.0	0.0
	FS	11.5*	2.2	36.0*	14.3*
Broadleaf signalgrass	SFS	0.0	0.0	0.0	0.0
	FS	2.0	10.8*	49.8*	12.0*
Browntop panicum	SFS	0.0	0.0	0.0	0.0
	FS	9.8*	2.2	37.0*	7.5*
Barnyardgrass	SFS	0.0	0.0	0.0	0.0
	FS	15.0*	15.0*	59.5*	11.4*
Large crabgrass	SFS	0.0	0.0	0.0	0.0
	FS	21.0*	0.0	43.5*	17.0*
Goosegrass	SFS	0.0	0.0	0.0	0.0
	FS	20.0*	11.8*	27.1*	7.9*
Itchgrass	SFS	0.0	0.0	0.0	0.0
	FS	29.5*	12.9*	76.9*	21.4*
Johnsongrass	SFS	0.0	0.0	0.0	0.0
	FS	51.9*	64.4*	73.9*	29.7*
Italian ryegrass	SFS	0.0	0.0	0.0	0.0
	FS	10.8*	0.0	21.2*	4.9*
LSD (0.05) ^d		6.0	5.4	13.3	6.9

^a Soil treatments included steam-treated field soil mixed 2:1 with sterile sand (SFS) and nonsterile field soil mixed with sterile sand (FS).

^b Each value represents a mean of 12 total replicates from two experiments. Means for individual weeds followed by * within a column are different ($P > 0.95$) from the corresponding SFS mean.

^c The percentage of root length colonized by *Pythium* was estimated for total *Pythium* spp. and *P. arrhenomanes* (*P. arrh.*).

^d Means for different weeds growing in FS (but not SFS) were compared within root disease variables using Fisher's Protected Least Significant Difference.

Table 5. Colonization by *Pythium* spp. and *P. arrhenomanes* of roots of eight weed species collected from sugarcane fields at two locations

Weed	Plants colonized by <i>Pythium</i> (%) ^a		Plants colonized by <i>P. arrhenomanes</i> (%) ^a		Root length colonized by <i>Pythium</i> (%) ^a		Root length colonized by <i>P. arrhenomanes</i> (%) ^a	
	St. Gabriel	St. John	St. Gabriel	St. John	St. Gabriel	St. John	St. Gabriel	St. John
Bermudagrass	83	74	67	43	68	51	5	3
Broadleaf signalgrass	90	84	73	58	49	69	7	4
Browntop panicum	79	61	42	61	62	50	3	5
Barnyardgrass	82	79	78	69	62	52	4	3
Large crabgrass	90	90	0	37	67	71	0	1
Goosegrass	70	65	31	49	20	40	3	4
Johnsongrass	90	90	77	80	77	87	71	10
Vaseygrass	90	90	70	79	76	63	7	5

^a Plants were collected from sugarcane fields at the St. Gabriel Experiment Station during October 1994 and the St. John the Baptist Parish during May 1995. Each value is a mean of 12 to 20 plants per location for each weed species. Values are the mean percentage of root length colonized by total *Pythium* spp. or *P. arrhenomanes* for 30 cm of roots from each plant.

***Pythium* infection of field-collected grass weeds.** In general, root rot symptoms were not evident in roots of plants collected from sugarcane fields. Cortical tissues of roots of weeds were often deteriorated and, in some instances, easily sloughed off. However, necrotic lesions were observed only in johnsongrass roots.

The percentage of plants with roots colonized by *Pythium* spp. was high for all weeds collected from both locations (Table 5). However, the percentage of plants colonized by *P. arrhenomanes* was variable among weed species (Table 5). Consistent, high frequencies of plant colonization by *P. arrhenomanes* were observed in johnsongrass, barnyardgrass, and vaseygrass (range = 69 to 80%) at both locations, whereas lower frequencies of plant colonization by *P. arrhenomanes* were observed in large crabgrass and goosegrass (range = 0 to 49%). Means for root length colonized by *P. arrhenomanes* under field conditions were less than for root length colonized by all *Pythium* spp. (Table 5). Goosegrass had the least amount of root length colonized by all *Pythium* spp., while johnsongrass had the highest *P. arrhenomanes* colonization level.

DISCUSSION

The results of pathogenicity tests, experiments with plants grown in field soil in the greenhouse, and isolation from roots of grass weeds collected from fields all indicate that weeds associated with sugarcane cultivation are hosts for *P. arrhenomanes*. These findings are in agreement with studies conducted in the northern great plains of North America (11,13).

P. arrhenomanes has a wide host range within the Poaceae; however, plants from other families also have been reported to be hosts (12). In the pathogenicity tests, purple nutsedge roots were colonized by *P. arrhenomanes* without any adverse effects on plant growth or root symptoms. Results from artificial inoculations performed in the greenhouse should be interpreted cautiously; nevertheless, it appears that purple

nutsedge may serve as a reservoir host for *P. arrhenomanes*.

Except for johnsongrass, weed species either did not show or developed only mild root rot symptoms when grown in field soil. One reason may be that the extent of root colonization by *P. arrhenomanes* appears to be lower under natural conditions in field soil. However, lack of symptom development in most of the weeds species examined suggests a lower level of susceptibility to *P. arrhenomanes* than for sugarcane. In other studies (1,2), weeds also were found to be symptomless hosts for plant pathogens. Garrett (5) suggested that weeds are more likely to serve as symptomless carriers for root pathogens than are cultivated crops.

The *P. arrhenomanes* colonization levels in pathogenicity tests were higher than those of plants grown in field soil or in field-collected roots. Roots of plants grown in field soil are subject to infection and colonization by other fungi, including different species of *Pythium*. The results suggest that root colonization by other *Pythium* species is associated with reduced frequency and extent of colonization by *P. arrhenomanes*. This agrees with a similar observation reported in sugarcane, where root colonization by a diverse *Pythium* population was associated with reduced infection and root rot caused by *P. arrhenomanes* (8).

The percent root length colonized by *P. arrhenomanes* in field-collected grass weeds usually was low. However, the frequency of plants infected with *P. arrhenomanes* for all weeds was 55% for plants collected during the fall and 60% for those collected during the spring. The frequency of colonization by *P. arrhenomanes* may vary depending on environmental and plant related factors, but the potential clearly exists for weed hosts to increase the amount of inoculum and to provide a means of persistence over time for *P. arrhenomanes*.

There was variation among weeds in incidence and extent of colonization by *P. arrhenomanes*. This variation could affect

their importance as alternative hosts. Crabgrass, goosegrass, and Italian ryegrass showed lower levels of colonization than did johnsongrass and itchgrass. The abundance of these weeds and the fact that they are favorable hosts for *P. arrhenomanes* suggest that johnsongrass and itchgrass could be important in the epidemiology of *Pythium* root rot.

The results of these investigations demonstrate that weeds serve as hosts of *P. arrhenomanes* in sugarcane fields. The grass hosts of *P. arrhenomanes* could play several roles in the epidemiology of sugarcane root rot, including serving as inoculum sources during the growing season and as a means of persistence during the winter and fallow periods. Since johnsongrass, itchgrass, and bermudagrass are the major weed problems in Louisiana sugarcane, they could play a role in increasing the incidence and severity of *Pythium* root rot. These results point to the importance of weed control, not only for reducing their competition with sugarcane, but also in possibly reducing soilborne pathogen inoculum levels.

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