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Host status of tropical spiderwort (*Commelina benghalensis*) for nematodes

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Nematodes are the most damaging pathogens of cotton and one of the most important pathogens of peanut. Weeds can support nematode reproduction and reduce the effectiveness of crop rotation as a management tool. This study documents the relative host status of tropical spiderwort for (1) the reniform nematode and the southern and peanut root-knot nematodes and (2) the fungal pathogen southern stem rot. A reproductive factor (RF) was calculated for each nematode (final number divided by initial number). Galling was estimated (0–10 scale) for the root-knot species. The southern root-knot nematode reproduced well on tropical spiderwort, with a gall rating of 3.1 and an RF of 15.5. The peanut root-knot nematode also reproduced well on tropical spiderwort, with a gall rating of 2.1 and an RF of 7.2. Trials with the reniform nematode were analyzed independently. In the first trial with the reniform nematode, the RF was 2.4 on tropical spiderwort and 1.4 on cotton. In the second trial, the RF was 3.6 on tropical spiderwort and 13.5 on cotton. The severity of symptoms caused by southern stem rot was estimated on a scale of 0 to 10. In the first trial, peanut had a disease severity rating of 4.0 and tropical spiderwort had a rating of 1.4, and the fungus could be seen growing on 40% of the tropical spiderwort plants. In the second trial, peanut had a disease severity rating of 10.0 and tropical spiderwort had a rating of 5.0, but the fungus could be seen growing on all of the tropical spiderwort plants. It appears that tropical spiderwort is a sufficiently good host for some of the primary nematode and fungal pathogens of major crops in the southeastern United States that its presence at typical plant population densities will greatly reduce the pathogen-suppressive effects of crop rotation.

Nomenclature: Tropical spiderwort, *Commelina benghalensis* L. COMBE; cotton, *Gossypium hirsutum* L.; peanut, *Arachis hypogaea* L.; peanut root-knot nematode, *Meloidogyne arenaria*, reniform nematode, *Rotylenchulus reniformis*; southern root-knot nematode, *Meloidogyne incognita*; southern stem rot, *Sclerotium rolfsii*.

Key words: Benghal dayflower, cotton, host status, *Meloidogyne arenaria*, *Meloidogyne incognita*, nematode reproduction, peanut, reniform nematode, root-knot nematode, *Rotylenchulus reniformis*.

Plant-parasitic nematodes are obligate parasites that can feed only on plants, so they will eventually starve if a suitable plant is not present. Most nematode species have a wide range of plants on which they can feed and reproduce (their host range), but host ranges do differ among nematode species. These differences are the foundation of crop rotation strategies to reduce nematode population levels. Additionally, host suitability generally is a continuum, with some plants supporting no reproduction (nonhosts), some supporting unfettered reproduction, and some supporting intermediate levels of reproduction. Nematodes do not distinguish between crops and weeds, and significant levels of nematode reproduction can occur on weeds, regardless of the host status of the current crop (Bélair and Benoit 1996; Davidson and Townshend 1967; Davis and Webster 2005; Gaur and Haque 1987; Tedford and Fortnum 1988; Venkatesh et al. 2000).

Peanut in the southeastern United States typically requires a 3-yr or greater rotation cycle to suppress soilborne fungal diseases such as southern stem rot, caused by *Sclerotium rolfsii* Sacc., and Cylindrocladium black rot (CBR), caused by *Cylindrocladium parasiticum* Crous, Wingfield, and Alfenas (Brenneman et al. 1995). The two primary crops grown in rotation with peanut in the Southeast are cotton and corn (*Zea mays* L.). In addition to suppressing fungal diseases, rotation sequences with these crops also can suppress plant-parasitic nematodes (Davis and Timper 2000; Davis et al. 2003; Gaur and Perry 1991).

Nematodes are the most damaging pathogens of cotton and one of the most important pathogens of peanut (Baird et al. 1996; Blasingame and Patel 2003; Dickson 1998; Koenning et al. 1999). The southern root-knot nematode [*Meloidogyne incognita* (Kofoid and White) Chitwood] reproduces well on cotton and corn, but not on peanut; the peanut root-knot nematode [*Meloidogyne arenaria* (Neal) Chitwood] reproduces well on peanut, but not on cotton or corn, and the reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira) reproduces well on cotton, but not on peanut or corn (Davis et al. 2003; Davis and Timper 2000). If the crop grown is a poor host or a nonhost for a nematode or fungal pathogen, the pathogen will still be able to reproduce if suitable weed hosts are present. The extent of reproduction on weeds will be influenced by the suitability of the weed host and the weed population density.

In the southeastern United States, annual losses from weeds (sum of crop yield reductions and costs of control)

in cotton, corn, and peanut were estimated to be $20 million, $42 million, and $64 million, respectively (Bridges 1992). Many important weed problems are similar among commonly grown crops and could be present each year regardless of crop rotation (Webster 2004, 2005). A significant emerging weed problem in the southeastern Coastal Plain is tropical spiderwort, also known as Benghal dayflower (Webster et al. 2005). This invasive weed spreads rapidly and usually reaches very high plant population densities in infested fields. In Georgia and Florida, tropical spiderwort was ranked as the most troublesome weed of cotton and among the top three most troublesome weeds of peanut (Webster 2005). Tropical spiderwort can also be a problem in corn, although peak emergence of tropical spiderwort occurs late enough in the growing season that corn yields have not been affected (Prostko 2005). In Georgia, tropical spiderwort infested an estimated 80,000 ha in 2005, and the range continues to expand (Webster et al. 2006). The increasingly frequent occurrence of tropical spiderwort in agronomic fields coupled with its status as a troublesome and difficult to control weed raises concern that tropical spiderwort could interact with other pests, potentially serving as a reservoir for nematodes and diseases that could otherwise be suppressed by crop rotation. Our primary objective in this study was to assess the suitability of tropical spiderwort as a host for the southern root-knot, peanut root-knot, and reniform nematodes. The host suitability for southern stem rot and CBR also was assessed.

Materials and Methods

The ability of the southern root-knot, the peanut root-knot, and the reniform nematodes to reproduce on tropical spiderwort was evaluated in a series of tests in a greenhouse. The ability of southern stem rot and CBR to cause disease symptoms on tropical spiderwort was also evaluated in separate tests. Each nematode test had four replicates in a completely randomized design and consisted of inoculated plants of tropical spiderwort and a susceptible standard. Each fungal test had five replicates arranged in a randomized complete block design and repeated over time. Tests of the fungal pathogens included both inoculated and noninoculated plants of tropical spiderwort and a susceptible standard.

Tropical spiderwort plants used in this study were grown from vegetative cuttings that were rooted in water for approximately 1 wk before transplanting into soil. All cuttings were derived from a single original source plant that had been collected from a field with a naturalized population in Grady County, GA. Cotton ('DP5415'), tomato (*Lycopersicon esculentum* Mill. 'Rutgers'), and peanut ('Georgia Green') plants were started from seed. Tomato was included as a susceptible standard in each test of the southern or peanut root-knot nematode; cotton was included for the reniform nematode, and peanut was included for southern stem rot and CBR. Plants were grown in square pots, with each pot containing one plant in 1,100 cm^3 of pasteurized soil (Tifton loamy sand; 83% sand, 9% silt, 7% clay, and $\leq$ 1% organic matter). Soil temperatures in the pots varied between 24 and 35 C during the study of nematode reproduction (soil temperatures were measured with a soil probe in one pot throughout each trial); temperatures were not measured during evaluation of the fungal pathogens.

Approximately 3 wk after planting, each pot was infested with 8,000 eggs of the nematode being evaluated. Inoculum of the southern root-knot nematode (race 3) and the peanut root-knot nematode (race 1) was collected from tomato roots ('Rutgers') and the reniform nematode was collected from cotton roots ('M-120 RNR') by agitating roots in 0.5% sodium hypochlorite solution for 2 min (Hussey and Barker 1973) 1 h or less before inoculation. Inoculum was distributed into two holes ($\sim$ 2.5 cm deep) and covered with soil. Pots were watered immediately after inoculation.

Nematode eggs were extracted from all roots in a pot 8 wk after inoculation. Roots were washed free of soil, cut into 5-cm pieces, and agitated in a 1% sodium hypochlorite solution in a 1-L flask for 4 min. For the southern and peanut root-knot nematodes, roots were evaluated for galling on a scale of 0 to 10, with 0 = no galling, 1 = 1 to 10% of the root system galled, 2 = 11 to 20% of the roots system galled, and so on to 10 = 91 to 100% of the root system galled. Eggs were collected and rinsed with tap water on nested 150- over 25-μm-pore sieves. For the reniform nematode, the number of vermiform nematodes in each pot was calculated from the number extracted and counted from a 150-cm^3 subsample of soil. Means separation was by Fisher's protected least significant difference test ($LSD_{0.05}$). A reproductive factor (RF) was calculated as RF = Pf/Pi, where Pf is the mean number of eggs extracted at the end of the test and Pi is the number of eggs applied as inoculum.

Evaluation of southern stem rot was done with a highly virulent isolate from peanut. The fungus was grown on potato dextrose agar, and 1-cm-diam plugs of mycelium and agar were collected for use as inoculum. Plugs were placed in pots at the soil line next to the plant. Plants were not wounded before inoculation in the first test, but a shallow 1-cm-long wound at the base of each plant was made immediately before inoculation in the second test. Treatments included noninoculated peanut and tropical spiderwort in addition to peanut and tropical spiderwort inoculated with southern stem rot. Pots were sealed after inoculation in large clear plastic bags and placed in the shade under a bench in the greenhouse where the air temperature ranged from 20 to 36 C. After 1 wk, the bags were removed, and 3 wk after inoculation, symptoms of disease were estimated on a scale of 0 (no symptoms) to 10 (dead plant). The presence or absence of signs of the pathogen also were noted. Data from the inoculations were subjected to ANOVA, and Fisher's protected LSD was calculated for the separation of means.

Evaluation of CBR (isolate CBR0413 from peanut in Seminole County, GA) was similar to that for southern stem rot with the following differences. The base of each plant was inoculated with one of two types of inoculum: a single 1-cm-diam agar plug per plant or 5 ml of a slurry made by blending the contents of two plates of CBR growing on potato dextrose agar in 200 ml of water. After inoculation, plants were placed into a chamber with 100% humidity at 20 C and a 12-h photoperiod for 3 wk. Disease was evaluated as described above.

Results and Discussion

A combined ANOVA verified that results between tests of the southern root-knot nematode were statistically similar ($P > 0.05$). The level of galling observed on tomato, the

TABLE 1. Symptoms and reproduction of the southern root-knot nematode and the peanut root-knot nematode on tomato and tropical spiderwort in separate greenhouse trials.

	Gall rating[a]	Eggs[b]	RF[c]
	Southern root-knot nematode		
Tropical spiderwort	3.14 a	123,814 a	15.5
Tomato	6.38 b	330,450 a	41.3
	Peanut root-knot nematode		
Tropical spiderwort	2.13 a	57,413 a	7.2
Tomato	6.29 b	99,329 b	12.4

[a] On a scale of 0 to 10, with 0 = no galling, 1 = 1–10% of the root system galled, 2 = 11–20% of the roots system galled, and so on to 10 = 91–100% of the root system galled. Means within a column followed by the same letter are not statistically different according to Fisher's protected LSD test ($P \leq 0.05$). Statistical analysis performed on data combined from two trials.

[b] Eggs were extracted from all roots in a pot 8 wk after inoculation.

[c] RF, reproductive factor = Pf/Pi, where Pf is the mean number of eggs extracted at the end of the test, and Pi is the number of eggs applied as inoculum.

susceptible standard, demonstrated the viability of the inoculum. Galling was significantly lower on tropical spiderwort than on tomato, although ~ 30% of the tropical spiderwort root system had galls (Table 1). The number of eggs extracted from tropical spiderwort was statistically similar ($P > 0.05$) to that extracted from tomato, although the number was numerically lower. An RF of 15.5 on tropical spiderwort proved that population levels of the southern root-knot nematode can increase greatly on this weed. The RF on tomato was 41.3.

Results with the peanut root-knot nematode resembled those for the southern root-knot nematode. A high level of galling was seen on tomato. Galling was significantly lower on tropical spiderwort than on tomato, although galling was observed on more than 20% of the tropical spiderwort root system (Table 1). The RF on tropical spiderwort (RF = 7.2) was 58% that on tomato (RF = 12.4). These data show that peanut root-knot nematode population levels can increase significantly on tropical spiderwort.

A combined analysis of variance showed that results between tests of the reniform nematode were statistically different, so the trials were analyzed independently. Reproduction was low in the first test even on the susceptible standard, with an RF of 1.4 on cotton and 2.4 on tropical spiderwort, and the number of eggs recovered did not differ between cotton and tropical spiderwort (Table 2). In the second test, the RF was 13.5 on cotton and 3.6 on tropical spiderwort, and the number of eggs recovered was greater on cotton than on tropical spiderwort. Reniform nematode reproduction is greater in soils with moderate levels of silt and clay, with one study putting the optimum of silt plus clay fractions at around 28% (Koenning et al. 1996), which is higher than the soil in our study. We believe this is why reproduction in this study was relatively low, even on cotton, which can support high levels of reproduction by this nematode. In soils that are more conducive to reniform nematode reproduction, the amount of reproduction on tropical spiderwort could be much higher than we observed. Tropical spiderwort is naturalized in the Coastal Plain of Georgia, Florida, and North Carolina (Krings et al. 2002; Webster et al. 2005), but isolated specimens have been collected in Louisiana in soils with higher silt and clay content (Thomas and Allen 1993).

TABLE 2. Symptoms and reproduction of the reinform nematode on cotton and tropical spiderwort in greenhouse trials.

	Trial 1		Trial 2	
	Eggs[a]	RF[b]	Eggs[a]	RF[b]
Tropical spiderwort	19,574 a	2.4	28,635 a	3.6
Cotton	11,356 a	1.4	107,604 b	13.5

[a] Eggs were extracted from all roots in a pot 8 wk after inoculation. Means within a column followed by the same letter are not statisically different according to Fisher's protected LSD test ($P \leq 0.05$). Numbers are means from two trials.

[b] RF, reproductive factor = Pf/Pi, where Pf is the mean number of eggs extracted at the end of the test, and Pi is the number of eggs applied as inoculum.

Nematode population levels are sometimes reported as nematodes per gram of root rather than the total number of nematodes produced, but those two measurements can result in different conclusions (Gast et al. 1984; Jordaan and De Waele 1988). The primary concern when nematodes reproduce on weeds is that nematode population density will increase or be maintained in a field. Total nematode reproduction, rather than nematodes per gram of root, addresses this concern more directly. Total reproduction in a field can be limited by the amount of weed root mass present, but tropical spiderwort is a vigorous plant that spreads rapidly and forms adventitious roots at the nodes, so root mass is unlikely to be a limiting factor.

Weeds, like crop plants, can support large increases in population levels (good hosts) for some nematodes and little or no increase (poor hosts) for others, and previous studies have shown that many common weeds are poor hosts for the nematodes included in this study. Many weeds in tobacco (*Nicotiana tabacum* L.) fields are relatively poor hosts for the southern root-knot nematode (race 3; Tedford and Fortnum 1988), and many weeds in vegetable fields are poor hosts for the reniform nematode (Queneherve et al. 1995). Some weeds common in the southeastern United States were good hosts for either the southern root-knot or reniform nematode, but not both, whereas many were poor hosts for both nematode species (Davis and Webster 2005). In contrast, tropical spiderwort is a moderately good to good host for all three of the nematodes tested: southern root-knot (race 3), peanut root-knot (race 1), and reniform nematodes. Tropical spiderwort supported less reproduction than the susceptible standards in this study. However, the high plant population density and abundant root mass of tropical spiderwort might support as much reproduction as would a susceptible crop.

Tropical spiderwort has been shown in previous studies to host nematodes. *Commelina* sp. was recommended as a ground cover to be grown when establishing banana plantations (Kasasian 1971), until it was found to be a host for the reniform nematode and the recommendation was changed (Edmunds 1971). Tropical spiderwort also was shown to be a host for the southern root-knot nematode (race not reported) in the Philippines (Valdez 1968) and for *Pratylenchus goodeyi* in eastern Africa (Mbwana et al. 1995). Tropical spiderwort was shown to be a host for *Meloidogyne javanica* in Kenya, and the weed showed significant galling in a field with a mixed population of *M. javanica* and the

Table 3. Symptoms and signs of southern stem rot on peanut and tropical spiderwort in greenhouse trials.

		Trial 1		Trial 2	
		Rating[a]	Signs[b]	Rating[a]	Signs[b]
			%		%
Peanut	Inoculated	4.0 n.s.[c]	100 a	10.0 a	100 a
	Noninoculated	1.0 n.s.	0 c	0.0 c	0 b
Tropical spiderwort	Inoculated	1.4 n.s.	40 b	4.6 b	100 a
	Noninoculated	0.0 n.s.	0 c	0.0 c	0 b

[a] On a scale of 0 (no disease symptoms) to 10 (dead plant).
[b] Percentage of plants showing visible signs that the pathogens were present (e.g., mycelium or sclerotia).
[c] Means within a column that are followed by the same letter are not significantly different according to Fisher's protected LSD test ($P \leq 0.05$). n.s., not significant.

southern root-knot nematode, although it was not proven that the southern root-knot nematode was infecting the plant (Desaeger and Rao 2000). Our study further documents tropical spiderwort as a host for nematodes, proving that this species of *Commelina* is a moderate to good host for race 3 of the southern root-knot nematode, race 1 of the peanut root-knot nematode, and the reniform nematode.

Southern stem rot caused disease symptoms approximately twice as severe on peanut as on tropical spiderwort (Table 3), although disease ratings were significantly different only in the second trial. Disease severity on inoculated peanut plants in the first trial was 4.0 (on a scale of 0 to 10), and the severity on tropical spiderwort was 1.4. In the second trial, the rating on peanut was 10.0 and the rating on tropical spiderwort was 4.6. The percentage of plants showing signs of the pathogen, such as hyphal growth and formation of sclerotia, was 100% for peanut in both the first and second trials, but 40% and 100% for tropical spiderwort in the first and second trials, respectively. This large difference in the first and second trials for tropical spiderwort was likely due to wounding the plants before inoculation in the second trial. Wounding would be less common in the field, so the first trial might be more indicative of the amount of reproduction that would take place in the field. Southern stem rot is a virulent pathogen that will kill a wide range of hosts. It is noteworthy that tropical spiderwort was able to survive complete girdling by southern stem rot lesions by forming new adventitious roots from nodes above the lesions. Such plants exhibited growth similar to the noninoculated controls.

Only one trial was completed with CBR, and it was not definitive. However, tropical spiderwort appears to be a relatively poor host for this pathogen.

Some variability in the host status of weeds for nematodes can be explained by genetic variability in weed populations (Griffin 1982), and this should be true for fungal pathogens as well. However, in our study, all of the tropical spiderwort in all of the trials was vegetatively propagated from one original plant, so there was no genetic variability. It is possible that differing levels of susceptibility exist within tropical spiderwort so that plants from other sources could exhibit differing levels of susceptibility to the pathogens tested in this study. It is not known if the plants in this study have levels of susceptibility that are typical for the species. In Georgia and Florida, at least two variations in tropical spiderwort plants exist (Faden 1993).

It appears that tropical spiderwort is a good host for some of the primary nematode and fungal pathogens of major crops in the southeastern United States. The presence of tropical spiderwort at plant population densities commonly observed in infested fields can greatly reduce the pathogen-suppressive effects of crop rotation. Similarly, the pathogen-suppressive benefit of host plant resistance to nematodes or diseases also could be reduced. Tropical spiderwort is such a vigorous, invasive, and competitive weed that controlling it is imperative regardless of its ability to host nematodes and diseases. But controlling tropical spiderwort also will be necessary if nematodes are to be controlled.

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