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DISEASE

Survival of Parasitic and Saprophytic Fungi on Intact Senescent Cotton Roots

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INTERPRETIVE SUMMARY

Following harvest in the fall, cotton plants are mowed to reduce boll weevil populations from overwintering in the stems. Under reduced tillage production systems the remaining base of the stem and roots is generally left undisturbed throughout the winter. Previous studies with vegetables and agronomic crops reported that pathogenic fungi can survive on residual plant tissues. In a preliminary investigation conducted in Georgia, living cotton roots harbored different anastomosis groups of *Rhizoctonia* AG and CAG, *Pythium,* and *Fusarium* spp., including *Fusarium oxysporum* and *F. solani*. It is uncertain, however, if undisturbed cotton roots may continue to harbor similar fungal pathogens which may infect cotton plants the following growing season. The objectives of this study were to survey undisturbed cotton roots for pathogenic and saprophytic fungi, and determine the pathogenicity of *F. oxysporum* cultures isolated from undisturbed debris on cotton seedlings.

Many fungal genera were isolated from the undisturbed cotton root tissues in this study. The most common fungi identified on the undisturbed cotton roots included *Alternaria, Chaetomium, Lasiodiplodia, Melanospora, Pestalotia, Phoma,* and *Trichoderma.* Similar population levels of fungi were cultured from tap and feeder roots. Isolation frequencies of the seedling disease pathogens, *Rhizoctonia solani* AG-4, *Pythium irregulare,* and *Pythium ultimum*, were low, but *F. oxysporum*, also responsible for damping-off of cotton seedlings, was commonly isolated from tap and feeder roots of undisturbed roots.

Do undisturbed cotton roots left after harvest increase overwintering densities of pathogenic fungi?

Pathogenic and saprophytic fungi were isolated from undisturbed cotton roots just prior to planting the following season. The levels, however, did not increase on the tap and feeder roots over the winter months.

Are cultures of *Fusarium oxysporum* isolated during the study pathogenic to cotton seedlings?

More than 90% of the cultures tested were pathogenic on cotton seedlings in the greenhouse. Mortality was low, ranging from 13 to 16%, and the remaining cotton seedlings survived the damage.

ABSTRACT

In reduced tillage and no-tillage production systems, crop debris is left undisturbed on the surface of the ground. This debris often harbors plant pathogens that may incite plant diseases. This survey was conducted to identify fungi associated with intact senescent cotton (*Gossypium hirsutum*) root systems in no-tillage production systems. Root systems were collected from Burke (southeast), Floyd (northwest), and Tift (southwest) counties in Georgia over 2 yr. Tissue sections (1 cm) of primary and secondary roots were assayed to determine mycobiota diversity monthly from December through April of 1994–1995 and 1995–1996. Forty genera of fungi were isolated including *Alternaria, Chaetomium, Curvularia, Melanospora,* and *Trichoderma.* Among the fungi isolated were several common boll rot pathogens, including *Lasiodiplodia, Pestalotia,* and *Phoma*. Mean isolation frequency for total fungi identified in 1995 was 8.8% on the primary roots to 8.1% on the secondary roots. In 1996, mean isolation frequency for total fungi was 14.8% from primary roots and 14% from secondary roots. Isolation frequencies of the important cotton seedling disease fungi *Rhizoctonia solani* AG-4 and *Pythium* spp. were low throughout the study, but these fungi were

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present in the roots collected just prior to cotton planting in April of both years. *Fusarium oxysporum*, responsible for seedling disease and wilt of mature plants, was routinely isolated from the root tissues throughout the sampling period. Pathogenicity tests of 30 isolates of *F. oxysporum* collected from the roots in 1995 and 60 isolates from 1996 were conducted on cotton seedlings in the greenhouse. Of the *F. oxysporum* isolates tested, 91.0% were pathogenic, and 13.5% and 15.7% of the isolates caused seedling death in greenhouse trials conducted in 1995 and 1996, respectively. Injury caused by the *F. oxysporum* isolates included cotyledon or leaf lesions, root tissue necrosis, and tap root pruning. Isolation frequency of *F. oxysporum* for all sites was greater than those for any other fungi identified during both years of the study. These results demonstrate that seedling disease and boll rot pathogens overwinter on intact senescent roots.

Cotton plants are mowed after harvest to destroy the stalks and reduce overwintering populations of adult boll weevils (*Anthonomus grandis* Boheman). In no-tillage and reduced tillage production systems, the remaining cotton stems and roots are left undisturbed until spring when fields are prepared for planting. Research with vegetables and agronomic crops has shown that pathogenic fungi can survive on residual plant tissues in conservation tillage production systems (Sumner et al, 1986, Wacha and Tiffany, 1979). *Verticillium dahlie* Kleb., which causes *Verticillium* wilt of cotton, survives and overwinters in cotton stalks and roots (Huisman, 1988; Wilhelm, 1955). Many boll rot pathogens including *Cephalosporium*, *Chaetomium*, *Curvularia*, *Mucor*, *Pestalotia*, *Rhizopus*, and *Trichothecium* survive on organic matter in cotton fields (Watkins, 1981). The boll rot pathogen, *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl., was routinely isolated from cotton stem debris in Georgia (R. Baird, 1996, unpublished data). Survival of plant pathogens on crop debris has contributed to an increase in disease severity on some crops in reduced tillage production systems (Cook et al., 1978; Rothrock et al., 1985; Sumner et al., 1986).

The objectives of this study were to: (I) survey undisturbed cotton roots left after harvest for overwintering populations of seedling disease, *Fusarium* wilt, and boll rot fungi, (ii) determine the pathogenicity of isolates of *F. oxysporum* Schl. isolated from undisturbed cotton roots on cotton seedlings, and (iii) document the occurrence of the associated saprophytic mycobiota.

MATERIALS AND METHODS

Cotton debris was collected from Burke (Southeast), Floyd (Northwest), and Tift (Southwest) counties after harvest in the 1994 and 1995 cotton production years. The Burke county site was a Dothan loamy sand (a fine-loamy, siliceous, thermic Plinthic Paleudult, 2–5% slope, pH 6.1) located at the Southeast Area Research Station in Midville, GA, planted in continuous cotton for 2 yr prior to initiation of the study. The Floyd county site was a Rome gravelly clay loam (a fine-loamy, mixed, thermic Typic Hapludult, pH 6.1), located at the Northwest Area Research Station at Rome and had a continuous cotton rotation 2 yr prior to the initiation of the study. Two different sites were used in Tift county. In 1994, the site in Tift county was a Tifton loamy sand (a fine-loamy, siliceous, thermic Plinthic Kandiudult, pH 6.0) located at the Rigdon Farm, Coastal Plain Experiment Station in Tifton, GA. Both had been in continuous cotton for the previous 3 yr. In 1995, plants were collected from a Tift loamy sand soil (pH 6.3) on the Johnson Farm near Tifton, a site which had been in continuous cotton for 3 yr prior to establishment of the test area.

All study sites were established in fields that were used for commercial production. Stalks were mowed in November of each year and then were disked, except for those in 0.2 ha plots that were not tilled and left undisturbed for this research. Plant debris was left on the soil surface and intact roots left undisturbed in the soil through April of the following year in these plot areas. The study plots ranged in size from 8 to 12 rows wide and contained at least 150 plants of the cotton cultivar, Deltapine 90 (DPL 90). Row spacing varied from 10.4 to 20.3 cm between plants. Fertility and weed control practices in the previous season followed state recommendations for cotton production (Crawford et al, 1995; Brown et al, 1996).

Intact root systems were collected during the first week of every month, starting in December and continuing through April of 1994–1995 and 1995–1996. In the first year, four plants were collected per location for each sampling date. In the second year, 10 plants were collected per location and sampling date. The roots from each location

were placed into paper bags, boxed, and shipped overnight to the Tifton laboratory and stored in a cold room at 10EC. All samples were assayed within 72 h of removal from the field.

Root Isolation

Ten 1-cm long pieces of tap and secondary roots were randomly selected from each root system. Tap and secondary root pieces were surface sterilized for 3 and 2 min, respectively, in a 0.525% w/v sodium hypochlorite solution. All root pieces were placed onto 100 by 15 mm plastic petri plates (two/plate) containing potato dextrose agar (PDA, Difco agar) amended with 8 mg/L of streptomycin sulfate, and 50 mg/L of chlortetracycline (Baird et al., 1991). Fungi growing from the root pieces were subcultured onto PDA for identification using macroscopic and microscopic morphological characteristics. More than one fungus was often isolated from a single piece of root tissue. Isolation frequencies based on the number of pieces of root tissue were determined for the genera and species isolated. Anastomosis groups of *Rhizoctonia* spp. were determined using previously described methods (Parmeter et al., 1969). Single spores of cultures initially identified as *Fusarium* spp. were transferred to carnation leaf agar and identified using the classification system of Nelson et al. (1983). Keys for general identification of the fungi were those developed by Ellis (1971), Sutton (1980), and Barnett and Hunter (1986).

Pathogenicity Tests

The pathogenicity of 30 isolates (10 per location) of *F. oxysporum* collected from cotton roots in 1995 and sixty (20 per location) collected in 1996 were evaluated on cotton seedlings in the greenhouse. Each isolate was grown on cornmeal-sand medium (CMS-cornmeal 15 g, sand 500 g, and 100 mL of water) for 14 d at room temperature. A total of 10 g of CMS was added to 1 L of pasteurized soil of Tifton loamy sand (pH 6.0), thoroughly mixed and placed into each pot (12 by 24 cm). In a randomized complete block design, five replicate pots were used per isolate. Three DPL-90 seeds were sown 3.0 cm deep in each pot. Pots were watered twice daily and temperatures in the greenhouse ranged from 10 to 28EC during the study period. Seedlings were observed 14-d after emergence and classified by the following symptoms: seedling death, root lesions, cotyledon lesions, leaf lesions, or symptomless. Individual seedlings displaying more than one symptom were counted more than once. All necrotic tissues from the cotyledon, hypocotyl, and roots were returned to the laboratory for plating on agar media. Necrotic tissues were sliced into 1 cm sections, surface-sterilized in 0.525% w/v sodium hypochlorite for 2 min, and plated onto PDA. All cultures were identified and compared to the original isolates using macroscopic and microscopic characteristics.

Statistics

Isolation percent of the most common fungi based on the number of root pieces was determined using the total number isolations for each site and year. These values were used to determine means and standard deviations of the number of isolates for the different fungi.

RESULTS AND DISCUSSION

A total of 4330 cultures including 40 genera of fungi was isolated from cotton roots collected at three locations in Georgia for 1995 and 1996 (Table 1). Ninety-six percent of the genera of fungi belonged to the Deuteromycetes. Among these fungi were several genera including *Alternaria, Aspergillus, Colletotrichum* (*Glomerella*), *Lasiodiplodia* (*Diplodia*), *Pestalotia, Phomopsis*, and *Phyllosticta*, that are important boll rot pathogens in Georgia (Roncadori et al., 1975; Bagga, 1968; Weindling et al., 1941). This inoculum may play a role in the development of boll rots in production fields. *Thielaviopsis basicola* (Berk. & Broome) Ferraris, which is an important soilborne pathogen in many cotton production states, was isolated only in 1995 from one location. Since other rapidly growing soil microorganisms may have prevented establishment of *T. basicola* on the plates, using PDA may have limited its isolation frequency.

Genera of ascomycetes isolated from the cotton roots were *Chaetomium, Glomerella, Melanospora,* and *Neocosmospora*. Several unidentified Basidiomycetes and seven anastomosis groups of *Rhizoctonia* spp. (AG-4, AG-3, AG-7, AG2-2, CAG-

Table 1. Isolation frequency of fungal genera from cotton roots at three locations in Georgia.

	Isolation frequency, %†					
	Burke County		Floyd County		Tift County	
Fungal genera	1995	1996	1995	1996	1995	1996
Ascomycetes						
Chaetomium	4.1	0.8	1.4	0.1	3.4	1.6
Glomerella	0	0	0.9	0	0	0
Melanospora	19.8	5.8	10.0	1.4	0	6.8
Neocosmospora	0.4	0.2	0	0.1	0.4	0.4
Basidiomycetes						
Unidentified Basidiomycetes	0	1.5	1.4	2.1	0	0
Rhizoctonia	2.9	4.0	0.1	6.7	0.5	1.6
Deuteromycetes						
Alternaria	1.7	10.6	7.2	12.6	1.1	5.5
Aspergillus	0	0.4	0	1.6	0	2.9
Botrytis	0	0	1.8	0	0	0
Cephalosporium	0	1.1	0	0	0	0
Cladosporium	0	0.3	0	0.5	0	1.1
Colletotrichum	0.8	0.5	0	2.4	0	1.4
Curvularia	0.4	0.1	0.5	0	0	0.7
Cylindrocladium	2.9	0	0.9	0	0	0
Epicoccum	0	0.4	0	2.0	0	0.5
Fusarium	26.7	32.6	32.5	29.9	38.3	22.7
Gleosporium	0	0	0.5	0	0	0.1
Humicola	0	0	0.9	0	0	0
Lasiodiplodia	14.5	8.1	0.9	2.3	39.8	5.2
Macrophoma	0	0	0	0	0	0.2
Macrophomina	0	4.0	0.5	0.3	0	0.1
Nigrospora	1.2	2.2	1.4	0.4	0.4	1.2
Paecilomyces	0	0	0.9	0	0	0
Penicillium	0.8	4.9	2.7	5.9	0	24.9
Pestalotia	6.6	5.8	2.7	7.0	4.1	5.3
Phoma	4.1	8.1	14.5	11.1	0.5	7.4
Phomopsis	0	0	0	0.2	0	0.9
Phyllosticta	2.9	0	2.7	0	0	0
Pithomyces	0	0	0.5	0	0	0
Sclerococcum	1.2	0	0	0	0	0
Thielaviopsis	1.2	0	0	0	0	0
Trichoderma	1.2	2.4	4.1	4.8	8.0	3.2
Verticillium	2.1	0	2.3	0	0.4	0
Volutella	1.7	0	0	0	0	0
Oomycetes						
Pythium	0.4	1.2	0	2.7	0.8	2.3
Zygomycetes						
Cunninghamella	0	0	0	0	0	0.1
Unidentified Fungi	1.7	4.9	15.8	6.0	1.5	4.1

† Sample size in 1995 = 240 (four root sections x two root types (primary and secondary) x 10 pieces (1 cm) per root type x three locations (Burke, Floyd, and Tift Counties) and sample size in 1996 = 600 (10 root sections x two root types (primary and secondary) x 10 pieces (1 cm) per root type x three locations). Number of isolations on which mean percent isolation values are based: 484 for Burke County, 442 for Floyd County, and 532 for Tift County in 1995; 1 437 for Burke County, 1 410 for Floyd County and 1 483 for Tift County in 1996.

2, CAG-3, and CAG-5) were also isolated. *R. solani* AG-4, the most common anatomosis group associated with roots during the study, is the most common seedling pathogen on cotton in Georgia (Sumner et al., 1995). Previously, isolates of *Rhizoctonia* spp. CAG-5 and *R. solani* AG-7 were found to be pathogenic on cotton in Georgia (Baird et al., 1995; Baird and Carling, 1997).

Pythium was the most common Oomycete collected during this investigation, but isolation frequencies were low. Even though the isolation frequency of *Pythium* spp. was low compared to other species, this inoculum may contribute to

Table 2. Mean isolation frequencies (%)† for the commonly isolated fungi in intact senescent cotton roots.

	Sampling dates									
	December		January		February		March		April	
Fungi	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996
Alternaria	0.1 (0.2)	2.2 (1.8)	0.7 (1.5)	1.0 (1.0)	0.4 (0.8)	1.3 (1.3)	0.1 (0.5)	0.9 (1.8)	0.0 (--)	1.4 (1.5)
Total *Fusarium* spp.	1.6 (1.8)	3.0 (3.1)	2.9 (3.0)	2.9 (2.7)	4.7 (3.5)	4.3 (3.0)	4.9 (3.2)	5.8 (4.4)	3.1 (3.9)	4.5 (3.6)
F. equisiti	0.1 (0.2)	0.7 (1.5)	0.1 (0.3)	0.6 (1.3)	0.6 (1.3)	1.0 (1.4)	0.8 (1.8)	1.2 (2.3)	0.5 (1.4)	1.2 (2.2)
F. oxysporum	0.6 (1.0)	1.3 (2.1)	1.3 (1.7)	1.2 (1.9)	0.6 (1.2)	1.5 (1.9)	1.2 (1.9)	2.6 (3.1)	2.3 (3.5)	2.0 (3.0)
F. sambucinum	0.1 (0.5)	0.2 (0.6)	1.2 (2.8)	0.2 (0.7)	2.3 (3.6)	0.4 (0.8)	1.3 (1.9)	1.1 (2.1)	0.2 (0.4)	0.3 (1.2)
F. solani	0.6 (1.2)	0.2 (0.6)	0.3 (1.0)	0.5 (1.0)	0.2 (0.5)	0.4 (0.8)	1.2 (2.0)	0.3 (0.2)	0.2 (0.5)	0.1 (0.3)
Lasiodiplodia	3.8 (4.7)	0.9 (1.4)	0.1 (0.5)	0.5 (1.1)	0.3 (0.8)	0.6 (1.0)	0.1 (0.3)	0.6 (1.5)	0.0 (--)	1.1 (2.7)
Pestalotia	0.3 (0.8)	0.6 (0.9)	0.2 (0.4)	0.4 (1.0)	1.0 (1.9)	1.0 (1.4)	0.2 (0.7)	1.1 (1.6)	0.0 (--)	1.2 (1.8)
Phoma	1.3 (2.9)	1.0 (1.4)	1.1 (1.7)	0.9 (1.3)	0.0 (--)	2.0 (2.0)	0.0 (--)	1.4 (1.4)	0.1 (0.5)	1.2 (1.5)
Rhizoctonia	0.6 (1.9)	0.2 (1.6)	0.2 (0.7)	0.4 (2.4)	0.1 (0.2)	0.3 (1.5)	0.2 (0.7)	0.1 (0.8)	0.0 (--)	0.1 (0.7)
Trichoderma	0.3 (0.6)	0.2 (0.5)	0.1 (0.2)	0.4 (0.8)	0.3 (0.8)	0.5 (1.0)	0.2 (0.2)	0.5 (1.1)	0.6 (1.3)	1.0 (1.9)
Total Fungi	10.7 (2.2)	13.6 (4.0)	10.0 (3.9)	14.0 (3.3)	9.2 (4.5)	14.7 (3.2)	7.4 (2.2)	15.2 (4.6)	5.0 (3.4)	14.6 (3.7)

† Mean isolation frequencies for each year and sampling date are in the column to the left and standard deviations are shown in parenthesis onthe right. Sample size in 1995 = 240 (four replicate roots x two root types (primary and secondary) x 10 pieces (1 cm) per root type x three locations (Burke, Floyd, and Tift Counties) and sample size in 1996 = 600 (10 replicate roots x two root types x 10 pieces (1 cm) per root type x three locations).

seedling disease. *Pythium* spp. are important seedling disease fungi that can significantly reduce plant stands when soils are moist and temperatures are 16EC or lower at planting (Baird, 1996). In northern portions of the state, including Floyd county, cotton is often planted in April when the soil temperatures are generally lower than 16EC at night (R. Baird, 1995, 1996, personal observations). These low, night soil temperatures inhibit seed germination and vigor, and increase growth of the fungus resulting in increased seedling disease. The most common species identified were *P. irregulare* Buisman and *P. ultimum* Trow (data not shown). Similar species of *Pythium* were identified in a previous investigation evaluating conservation tillage in a cotton-soybean (*Glycine max* L. Merr.) double-cropping production system (Sumner et al., 1995).

Mean frequency of isolation for the commonly occurring fungi or genera varied among months, but no consistent trends were observed (Table 2). In general, a similar spectrum of genera or species was observed during the entire sampling period. Total fungi isolated across months were greatest in December 1995 at 10.7% and lowest in April at 5.0% in 1995. Mean isolation frequencies were

Table 3. Mean isolation frequencies (%)† of the commonly isolated fungi from intact senescent cotton roots at three locations in Georgia.

	Primary roots				Secondary roots			
Fungi	1995		1996		1995		1996	
Alternaria	0.4	(1.1)	1.2	(1.8)	0.2	(0.5)	1.5	(1.7)
Total *Fusarium* spp.	3.9	(4.0)	4.5	(3.8)	2.9	(2.5)	3.7	(3.2)
F. equisiti	0.4	(1.4)	1.1	(2.2)	0.4	(1.0)	0.7	(1.3)
F. oxysporum	1.2	(2.2)	1.8	(2.5)	1.2	(2.0)	1.7	(2.5)
F. sambucinum	1.5	(3.0)	0.5	(1.4)	0.6	(1.1)	0.4	(1.2)
F. solani	0.5	(1.2)	0.3	(0.7)	0.5	(1.2)	0.2	(0.6)
Lasiodiplodia	0.9	(2.8)	0.8	(2.0)	0.8	(2.4)	0.7	(1.2)
Pestalotia	0.2	(0.8)	0.9	(1.5)	0.4	(1.2)	0.8	(1.3)
Phoma	0.4	(1.7)	1.2	(1.6)	0.6	(1.5)	1.3	(1.6)
Rhizoctonia	0.0	(--)	0.2	(1.4)	0.4	(1.3)	0.2	(1.7)
Trichoderma	0.2	(0.6)	0.6	(1.5)	0.3	(0.9)	0.5	(0.7)
Total fungi	8.8	(3.4)	14.8	(4.1)	8.1	(4.3)	14.0	(3.5)

† Mean isolation frequencies are shown on the left and standard deviations are in parenthesis. Sample size in 1995 = 1 200 (four replicate roots x two root types (primary and secondary) x 10 pieces (1-cm) per root type x three locations (Burke, Floyd, and Tift Counties) x five sampling dates) and sample size in 1996 = 3 000 (10 replicate roots x two root types x 10 pieces (1 cm) per root type x three locations x five sampling dates).

Table 4. Frequency of isolation of *Fusarium* spp. recovered from cotton roots at three locations in Georgia.

	Isolation frequency, %†					
	Burke County		Floyd County		Tift County	
Species	1995	1996	1995	1996	1995	1996
F. equisiti	1.4	6.5	6.5	8.5	6.3	3.9
F. graminearum	0	2.1	1.4	0.5	1	0
F. nivale	6.6	1.3	2.4	1.8	4.8	2.1
F. oxysporum	5.0	4.4	6.3	4.1	9.3	4.3
F. sambucinum	8.7	19.0	6.3	4.5	10.5	12.3
F. solani	0	0.2	4.8	0.2	1	0
Other species‡	5.0	0.9	4.8	6.2	5.4	1.4

† Sample size in 1995 = 240 (four root sections x two root types (primary and secondary) x 10 pieces (1 cm) per root type x three locations (Burke, Floyd, and Tift Counties) and sample size in 1996 = 600 (10 root sections x two root types x 10 pieces (1 cm) per root type x three locations). Number of isolations per root on which mean percent isolation values are based: 484 for Burke County, 442 for Floyd County, and 532 for Tift County in 1995; 1 350 for Burke County, 1 307 for Floyd County, and 1 519 for Tift County in 1996.

‡ Isolation frequencies (%) of five other species of *Fusarium*.

higher during the last three sampling dates in 1996.

Mean isolation frequencies of all fungi from primary and secondary roots were similar both years (Table 3). *Rhizoctonia* was isolated exclusively from the secondary roots in 1995, but was cultured from both tap and secondary roots in 1996. Frequency of isolation of all *Fusarium* spp. from primary and secondary (feeder) roots was 3.9 to 4.5%, respectively in 1995, and 2.9 to 3.7%, respectively in 1996 (Table 3).

Six species of *Fusarium* were isolated and identified from the cotton roots during this investigation. The most common species were *F. sambucinum* Fuckel, *F. oxysporum*, and *F. equisiti* (Table 4). *Fusarium oxysporum* was the most common species isolated from the three locations over both years (Table 5). However, throughout the study, *F. equisiti* (Corda) Sacc., was isolated more frequently than *F. oxysporum* from Floyd county.

Of the 30 isolates of *F. oxysporum* from 1995 and 60 from 1996 tested for pathogenicity in the greenhouse, 91% were pathogenic on cotton seedlings (Table 6). Seedling symptoms ranged from minor lesions on roots, hypocotyl, or cotyledons to seedling mortality. At 14 d after planting, 13.5% of the isolates in 1995 and 15.7% of the isolates in 1996 caused seedling mortality. Less than 1% of the *F. oxysporum* isolates caused hypocotyl lesions, but 77.4 and 83.1% of the isolates resulted in secondary or tap root infections in 1995 and 1996, respectively. *Fusarium oxysporum* was re-isolated from all the infected seedlings.

Isolates of *Fusarium* spp. have previously been shown to be pathogenic on seedling cotton (Colyer, 1988; Zhang et al, 1996). *Fusarium oxysporum* root infections that occur during the seedling stage generally cause minor damage, but can continue to progress during stressful periods of plant growth resulting in reduced root health and size (Zhang et

Table 5. Mean isolation frequencies (%)† of the most commonly isolated fungi from three locations in 1995 and 1996.

	Burke County				Floyd County				Tift County				
Fungi	1995		1996		1995		1996		1995		1996		Total
Alternaria	0.1	(0.3)	1.5	(1.7)	0.6	(1.3)	1.8	(1.7)	0.7	(0.4)	0.8	(1.1)	5.5
Total *Fusarium* spp.	3.5	(3.1)	4.7	(3.8)	2.3	(2.3)	4.2	(3.9)	4.4	(4.1)	3.4	(2.8)	22.5
F. equisiti	0.3	(1.1)	0.9	(1.5)	0.9	(1.7)	1.3	(2.4)	0.1	(0.4)	0.6	(1.2)	4.1
F. oxysporum	1.8	(2.9)	2.7	(3.2)	0.6	(1.1)	0.7	(1.2)	1.2	(1.8)	1.8	(2.4)	8.8
F. sambucinum	0.5	(1.0)	0.1	(0.4)	0.1	(0.4)	1.0	(2.0)	2.5	(3.5)	0.2	(0.5)	4.4
F. solani	0.6	(1.3)	0.2	(0.6)	0.6	(1.1)	0.3	(0.8)	0.6	(1.6)	0.2	(0.5)	3.5
Lasiodiplodia	0.9	(2.7)	1.2	(2.0)	0.3	(0.8)	0.3	(0.8)	1.4	(3.4)	0.8	(1.8)	4.9
Pestalotia	0.5	(1.1)	0.8	(1.6)	0.1	(0.6)	1.0	(1.4)	0.4	(1.3)	0.8	(1.2)	3.6
Phoma	0.4	(1.1)	1.2	(1.6)	1.1	(2.4)	1.6	(1.8)	0.0	(--)	1.1	(1.2)	5.4
Rhizoctonia	0.2	(0.8)	0.2	(1.6)	0.0	(--)	0.3	(1.8)	0.4	(1.4)	0.1	(1.1)	1.2
Trichoderma	0.1	(0.4)	0.4	(0.8)	0.5	(1.1)	0.7	(1.3)	0.2	(0.5)	0.5	(1.3)	2.4
Total fungi	8.8	(3.7)	14.4	(3.9)	8.7	(3.8)	14.1	(4.3)	7.9	(4.2)	14.8	(3.3)	68.7

† Mean isolation frequencies for each year and sampling date are in column to the left and standard deviations are shown in parenthesis on the right. Sample size in 1995 = 240 (four root sections x two root types (primary and secondary) x 10 pieces (1 cm) per root type x three locations (Burke, Floyd, and Tift Counties) and sample size in 1996 = 600 (10 root sections x two root types x 10 pieces (1 cm) per root type x three locations).

Table 6. Pathogenicity of isolates of *Fusarium oxysporum* isolated from undisturbed cotton roots on cotton seedlings in the greenhouse.

	Percent seedlings displaying symptoms†	
Symptom	**1995**	**1996**
Seedling mortality, visible stem cankers	**14.2**	**16.5**
Cotyledon lesions	**33.1**	**69.4**
Leaf lesions	**10.8**	**16.9**
Root lesions, tap and secondary	**77.4**	**83.1**
Symptomless seedlings	**8.3**	**9.1**

† A total of 30 isolates was evaluated in 1995 and 60 in 1996. Total percent for each year is > 100 since individual seedlings displaying more than one symptom were counted more than once.

al, 1996). Reduced root biomass becomes important if other stress factors, such as nematodes, insects or drought, affect plant growth during the season. These latent or minor infections by *F. oxysporum* also may be responsible for Fusarium wilt of mature cotton plants in fields. *Fusarium oxysporum* f. sp. *vasinfectum* is responsible for seedling death and *Fusarium* wilt of cotton (Watkins, 1981).

Species of fungi known to cause seedling disease, leaf spot, and boll rot of cotton were isolated from senescent cotton roots remaining in no-tillage cotton fields throughout the sampling period of this 2-yr study. This cotton root debris was still present in cotton fields prior to planting the following season and may provide inoculum that contributes to disease development in cotton production fields. Early plowing of fields may be important to increase the degradation of plant tissues and reduce the survival of plant pathogenic fungi, particularly in areas of the state where annual disease pressure is high. Further studies should be conducted to determine the effects of conservation or no-tillage practices on population levels of these organisms and subsequent disease incidence in fields planted continuously in cotton.

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