Effect of Pythium irregulare on Cotton Growth and Yield, and Joint Action with Other Soil-Borne Pathogens

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ABSTRACT

In field experiments, certain symptoms of Pythium root rot of cotton, primarily an early-season disease, persisted throughout much of the growing season. Seed cotton yield of plants infected with *P. irregulare* was 11-14% less than that of the controls. However, height growth was only retarded for 2-3 mo after transplanting, and differences were not evident at harvest. In greenhouse studies, *Pythium*-infected and check plants were transplanted into fumigated and nonfumigated soils, which had been collected from three different field locations in Georgia. Soil from two of the sites contained mixtures of plant parasitic nematodes; that from the third site was infested with root knot nematode and the Fusarium wilt fungus. In all fumigated soils, reduced shoot growth caused by Pythium root rot was evident only 75-90 days after transplanting, and final root growth and boll production were only slightly decreased. Check transplants grew vegetatively and fruited better in fumigated than in nonfumigated soils, indicating the harmful activity of certain native soil-borne pathogens. The growth of infected transplants in one nonfumigated field soil sample suggested the action of a nematode-Pythium root rot complex. Both shoot growth and boll production were reduced to a greater degree by joint pathogen activity, than when either the nematodes or fungus attacked individually, suggesting an additive effect.

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Additional key words: Gossypium hirsutum, nematodes, Fusarium wilt.

In the southeastern United States, Pythium root rot may significantly reduce vegetative growth of young cotton plants when the early portion of the growing season is cool and moist. Since disease development is often arrested by both warmer soil temp and plant maturation (9), the disease is primarily an early-season problem. Consequently, little is known about symptom persistence in older plants.

Pythium spp. have been isolated frequently from plants showing cotton stunt (2); however, the perpetuation of severe symptoms throughout the warmer portion of the growing season in certain fields suggested the involvement of other factors. Severe seedling root damage, caused by soil-borne pathogenic fungi and subsequent moisture stress, can reduce yield (10). Reynolds and Hansen (7) attributed increased seedling disease severity, and decreased cotton yield, to a *Meloidogyne-Rhizoctonia* complex. Interactions between seedling disease fungi and various other pathogenic nematodes also increased symptom severity on young plants (3), but their effects on older plants have not been studied. *Pythium ultimum* may interact with other fungal soil-borne pathogens to accentuate disease development. Kerr (6) demonstrated that this fungus is an important component in the root rot-Fusarium wilt complex of peas. Therefore, we evaluated the role of *P. irregulare* Buis. as a contributing factor in cotton stunt by determining the persistence of symptoms resulting from early season root rot, and the possibility of the fungus interacting with other soil-borne plant pathogens in a disease complex. A preliminary report on a portion of this work has been published (8).

MATERIALS AND METHODS.—In all studies, root rot and stunting were induced by growing plants in artificially infested soil kept in water-bath temp tanks. Inoculum of *P. irregulare* was grown and incorporated into methyl bromide-treated soil using the method and rate described by Roncadori and McCarter (9). Either infested or check soils were placed in 10-cm (top diam) pots and four seed of *Gossypium hirsutum* L. 'Coker 201', treated with Ceresan L (1.3 g/kg of seed), were planted in each container. To avoid seedling mortality, the soil temp was maintained at 29 to 30 C for 10 days after seeding. The seedlings were then thinned to one per pot, an attempt being made to select those of uniform height, and the temp was reduced to 16 to 17 C until transplanting.

Soils were assayed for nematodes by the use of a modified centrifugal-flotation technique (5), and nematodes were recovered from roots by the method described by Bird (1). *Pythium* populations in soils were determined by using the modified Kerr's dilution plate method (4).

Field studies.—To determine the effect of Pythium root rot on plant growth and seed cotton yield, 6-wk-old transplants were set out in field plots located at Athens and Midville, Georgia, where soil assays indicated that *Pythium* spp. and nematodes were not a problem. Transplanting was done the third wk of May at both locations in both 1971 and 1972. Treatments were arranged in a randomized block design and replicated five times. Replications of each treatment consisted of two rows 6 m long spaced 1 m apart with 0.3 m between individual plants within the rows. Height growth was measured at transplanting and on a monthly basis thereafter, until differences between treatments were no longer evident. The plots received routine cultural maintenance and were hand-harvested during the first 2 wk of November of each year.

Greenhouse studies.—To detect interactions between *P. irregulare* and other soil-borne pathogens, soils were collected from three different coastal plain locations in Georgia during December, 1971. The selected sites were mainly nematode problem areas during the preceding growing season. Soil from site A contained a high population density of *Hoplolaimus columbus* Sher. and low densities of *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans-Stekhoven and *Trichodorus* spp. (Table 3); soil from site B had low populations of

Meloidogyne incognita (Kofoid and White) Chitwood, *P. brachyurus*, *Trichodorus* spp., and *Tylenchorhynchus* spp.; and soil from site C was highly infested with *M. incognita* and *Fusarium oxysporum* Schlecht f. sp. *vasinfectum* (Atk.) Snyd. and Hans. The soils were screened to remove coarse debris and mixed with vermiculite (3:1, v/v). Fertility and pH were adjusted where necessary to provide optimum conditions for cotton growth. Soils were placed in polyethylene pots (27-cm top diam) and 20 containers from each of the three sites were fumigated with methyl bromide (454 g/20 pots). An additional 20 pots of soil from each site were left untreated. Nine-wk-old plants with Pythium root rot were transplanted to 10 pots each of the fumigated and untreated soils. The remaining 10 pots of each soil received appropriate check transplants. The pots were placed on greenhouse benches, where the ambient temp ranged from 20 to 32 C. The study was terminated after 5 mo, a period which approximated a growing season in the field.

RESULTS.—*Field studies.*—Plants with Pythium root rot were stunted significantly for 9-10 wk after transplanting at both field locations (Table 1). After this period, root rot did not restrict vegetative growth and, consequently, differences between treatments were not evident at harvest. The data presented for 1972 are similar to those obtained during 1971.

Seed cotton yield at Athens was significantly reduced by root rot by 11% in 1971, and by 14% in 1972. During 1972, plants with root rot averaged 52 g of seed

TABLE 1. Effect of Pythium root rot on height growth of cotton at two field sites in Georgia during 1972

Location	Days after transplanting[a]	Plant height (cm)		% reduction in growth
		Check	Pythium root rot	
Athens	0[a]	18.9*[b]	13.2	30
	40	23.2*	16.0	31
	67	55.1*	44.8	19
	92	88.9	86.7	2
Midville				
	0	18.6*	12.6	32
	37	25.1*	17.3	31
	65	61.1*	49.6	19
	101	95.1	91.3	4

[a]Six-wk-old transplants were set out 17 May at Athens and 16 May at Midville.
[b]*Indicates that row means were statistically different, $P = 0.05$.

TABLE 2. Effect of Pythium root rot on root growth and boll production in fumigated and nonfumigated field soils in the greenhouse

Soil site and soil treatment	Avg. root wt/plant (g)	Avg. bolls/plant[a] (no.)
Site A		
Fumigated		
Check[b]	137.4 A[c]	10.8 A
Pythium	102.0 B	10.7 A
Nonfumigated		
Check	55.2 C	8.1 B
Pythium	41.5 C	5.4 C
Site B		
Fumigated		
Check	97.0 A	11.2 A
Pythium	88.4 A	9.2 B
Nonfumigated		
Check	114.7 A	8.9 B
Pythium	110.5 A	7.6 B
Site C		
Fumigated		
Check	107.1 A	10.5 A
Pythium	97.0 A	8.8 A
Nonfumigated		
Check	58.3 B	5.2 B
Pythium	42.4 B	4.8 B

[a]Includes total of opened and mature-green bolls.
[b]Both check and Pythium-infected plants (9-wk-old) were transplanted into the treated soils.
[c]Column means followed by a different letter are significantly different, $P = 0.05$.

cotton/plant, compared to 61 g/plant in the controls. Significant yield differences were not obtained at Midville during 1972 and data were not available during 1971.

Greenhouse studies.—Persistence of stunting, initially caused by *P. irregulare,* varied depending upon the soil treatment and the field soil used. In all fumigated soils, height growth of plants with root rot was retarded for 75 to 90 days after transplanting (Fig. 1). At harvest, however, differences in height growth were not visible. Root wt was reduced significantly by *P. irregulare* only in fumigated soil from site A, whereas boll yield was decreased only in fumigated soil from site B (Table 2).

Vegetative growth and fruit yield differences between check plants grown in fumigated soils and those grown in nonfumigated soils indicated a deleterious effect caused by indigenous soil-borne pathogens (Fig. 1, Table 2). Reduced height growth was evident 30 days after transplanting into nonfumigated soils A and C and was 14-23% less than the growth of plants in fumigated soils at harvest. Both root growth and boll production were also retarded significantly in plants grown in nonfumigated soils of the same two samples (Table 2).

An additive joint action between *P. irregulare* and certain nematodes was suggested in soil A, which had population increases in *H. colombus, P. brachyurus,* and *Trichodorus* spp. In nonfumigated soil, both height growth and yield were reduced to a greater degree by the combined activity of *Pythium* and parasitic nematodes, than by either of those pathogenic agents separately (Fig. 1 and Table 2). Root wt was not significantly affected by their joint activities; however, the plants exhibited less feeder root growth and more necrosis than did the controls transplanted into nonfumigated soil.

Most nematode populations exceeded their initial densities during the study, indicating that extensive feeding and reproduction had occurred (Table 3). The population of *H. columbus* had the lowest increase, whereas populations of *P. brachyurus* and *Trichodorus* spp. increased most rapidly. Pythium root rot had no significant effect on nematode reproduction, therefore, the data are averages of population counts of both treatments.

The incidence of plant mortality, due to Fusarium wilt in soil C, was not affected by *P. irregulare.* Forty percent mortality occurred both in the controls and plants with root rot grown in nonfumigated soil. However, wilt symptoms were initially evident 60 days after transplanting in plants affected by *P. irregulare,* and appeared 2 wk later in the controls.

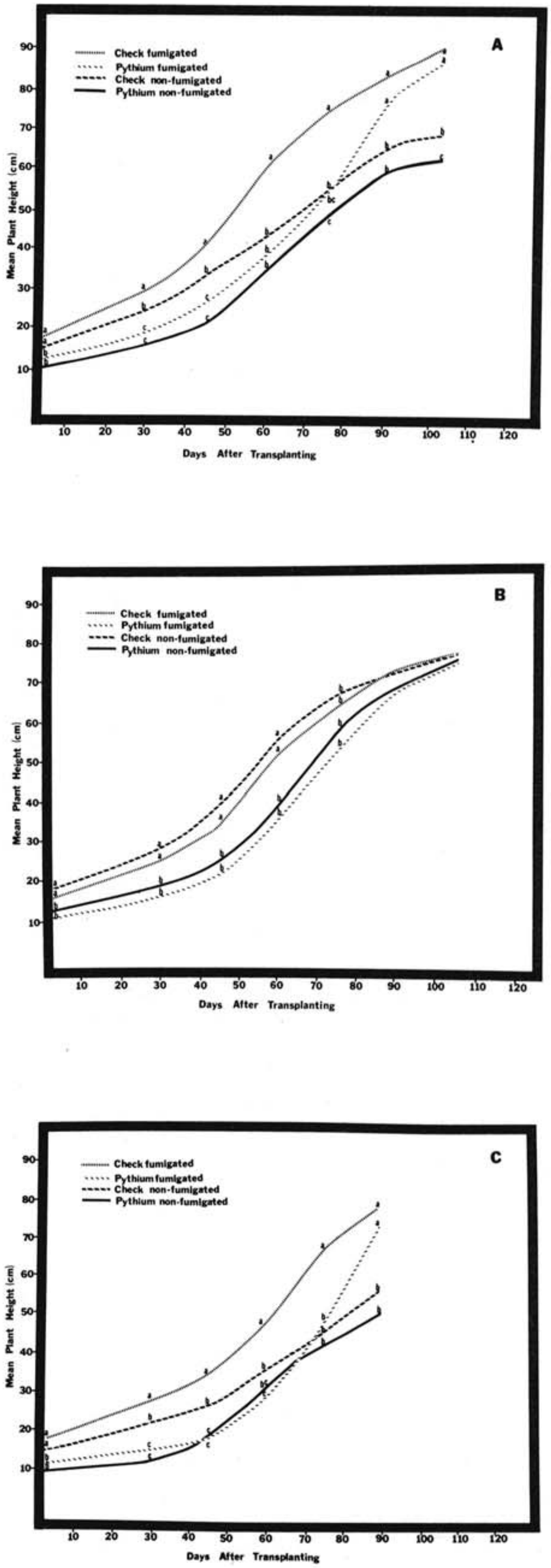

Fig. 1-(A to C). Height growth of 9-wk-old check and Pythium-infected cotton transplants grown in fumigated and nonfumigated soils previously collected from three different problem fields in Georgia and maintained in the greenhouse. **A)** Sample contained mixed populations of *Hoplolaimus columbus, Pratylenchus brachyurus,* and *Trichodorus* spp. **B)** Sample contained mixed populations of *Meloidogyne incognita, P. brachyurus, Tylenchorhynchus* spp., and *Trichodorus* spp. **C)** Sample contained mixed populations of *M. incognita* and *Trichodorus* spp. and *Fusarium oxysporum* f. sp. *vasinfectum.* (Note: height means for various treatments at a given time are significantly different when followed by a different letter, $P = 0.05$).

TABLE 3. Nematode population changes in nonfumigated field soils transplanted to cotton in the greenhouse

	No. nematodes/pot[a]					
	Site A		Site B		Site C	
Nematode	Initial population	Final population	Initial population	Final population	Initial population	Final population
Hoplolaimus columbus	9,434	12,206	0	0	0	0
Meloidogyne incognita[b]	0	0	810	11,086	11,745	21,883
Pratylenchus brachyurus	135	12,759	810	7,437	6	0
Tylenchorhynchus spp.	0	0	1,080	14,149	0	0
Trichodorus spp.	405	28,894	810	31,658	0	8,303

[a]One pot contained 13,500 cc of soil. Final populations are based on nematodes in soil and root and are averages of counts in both the controls and in pots containing plants infected with *Pythium irregulare*.

[b]Larval counts in soil only.

DISCUSSION.—*Pythium irregulare* is most active as a root rot pathogen on cotton early in the spring (9). Nevertheless, the present studies indicate that certain other symptoms, such as poor shoot growth and yield, are variable and may persist throughout much of the growing season. Seed cotton yield of plants with root rot was reduced for two consecutive years in field tests at Athens, and decreased boll production occurred on plants grown in a fumigated field soil in the greenhouse. In all studies, shoot growth was retarded only temporarily. However, in the greenhouse study involving fumigated field soils, poor root growth of infected transplants in soil from one of the sites persisted until harvest.

In the latter stages of the studies, vegetative growth of Pythium-infected plants sometimes exceeded that of the controls, which had already initiated flowering and boll set. This earlier shift to the reproductive cycle by the controls, along with a corresponding decrease in vegetative development, resulted in a slower vegetative growth rate than that of the infected plants which had not yet fruited heavily.

Under field conditions, seed cotton yield reduction caused by Pythium root rot was affected by the time of crop maturity since affected plants flowered and matured a crop later than did the controls. At Athens, the short growing season allowed maturation and opening of the entire boll crop on the controls prior to frost, but some of the bolls failed to open on plants with root rot. However, the longer growing season at Midville provided sufficient time for boll maturation and dehiscence regardless of treatment and, consequently, a yield difference was not evident.

A nematode-Pythium root rot complex involving *H. columbus* and perhaps other plant parasitic nematodes was suggested in the field soil from site A in the greenhouse study. Reduced height growth and yield, associated with either the fungus or the nematodes, were not as great as the symptoms caused by the combined activities of both agents, thus indicating an additive effect. Since Pythium root rot occurs early in the growing season, subsequent nematode feeding throughout the remainder of the year, along with an unfavorable environment, could provide a stress which would perpetuate the symptoms and be a contributing factor to cotton stunt. The role of other segments of the soil microflora was not determined, therefore, a study of the *P. irregulare*-nematode interaction in fumigated soils is needed to determine more precisely the effects caused by this disease complex.

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