Role of Nematodes and Soil-borne Fungi in Cotton Stunt[1]

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Abstract: The nematodes, *Pratylenchus brachyurus*, *Trichodorus christiei*, and *T. porosus* and the soil-borne fungi, *Rhizoctonia solani*, *Pythium debaryanum*, *P. irregulare*, *P. ultimum*, and *Fusarium* spp. were the pathogens most frequently found in the roots and rhizosphere of field-grown cotton (*Gossypium hirsutum*) showing "stunt" symptoms. Field-plot application of the nematicide D-D (1,2-dichloropropane, 1,3-dichloropropene) at 373.4 liter/ha (40 gal/A) significantly increased plant growth and yield. A fungicidal mixture of Dexon (p-dimethyl-aminobenzenediazo sodium sulfonate at 23.5 kg/ha (21 lb/A) and Terraclor (pentachloronitrobenzene at 25.2 kg/ha (22.5 lb/A) was phytotoxic, but combined nematicide/fungicide treatments were not. Greenhouse temperature-tank experiments in soils from two locations showed significantly improved root and shoot growth following methyl bromide fumigation at both 25 C and 18 C and more severe "stunt" at the lower temperature. *Key Words: Pratylenchus brachyurus*, *Trichodorus christiei*, *Trichodorus porosus*, Soil-borne fungi, *Fusarium* spp., *Pythium* spp., *Rhizoctonia* spp., Cotton, *Gossypium hirsutum*, Fumigation, Methyl bromide, 1,2-dichloropropane, 1,3-dichloropropene, Soil fungicide, p-dimethylaminobenzenediazo sodium sulfonate, Pentachloronitrobenzene.

Cotton "stunt" has recently become increasingly severe in the southeastern part of the cotton belt. Symptoms appear in the seedling stage and intensify with plant maturity, particularly during a cool, wet spring and hot, dry summer. Cotton stunt is usually localized in a field but may be more generalized and is often most severe in sandy soils. In addition to retarded root and shoot growth, plants frequently exhibit browning of epidermis and cortex of the hypocotyl, tap root necrosis and mortality, and browning of young secondary roots. Field-grown plants showing symptoms during the first 30 days after planting are usually stunted throughout the growing season and produce low yields.

A survey of approximately 100 "stunted" cotton fields in Georgia indicated plant-parasitic nematodes and seedling disease fungi are often associated with stunted plants. The nematodes recovered in this survey and the percent of problem fields in which they occurred were: *Criconemoides* spp., 83%; *Trichodorus* spp., 65%; *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans Stekhoven, 32%; *Helicotylenchus* spp., 30%, *Meloidogyne incognita* (Kofoid and White) Chitwood, 24%; *Hoplolaimus* spp., 9%; *Rotylenchulus reniformis* Linford and Oliveira, 9%; *Tylenchorhynchus* spp., 7%; *Xiphinema* spp., 7%; and *Hemicycliophora* spp., 4%. *Helicotylenchus multicinctus* (Cobb) Golden and *Hoplolaimus columbus* Sher were the most commonly isolated species of these two genera, whereas *Trichodorus christiei* Allen and *T. porosus* Allen were the only species of *Trichodorus* observed. *Rhizoctonia solani* Kühn, *Pythium* spp., particularly *P. debaryanum* Hesse, *P. irregulare* Buis, and *P. ultimum* Trow, and *Fusarium* spp. were the fungi most commonly isolated from soil and roots.

Although some plant-parasitic nematodes are pathogenic to cotton (1, 3, 4, 9) and much is known about cotton seedling diseases (2, 5, 10, 11, 13), little is known about the association of soil-borne microorganisms with "stunted" cotton throughout the growing season. Cotton stunt has been attributed to nonbiotic factors such as soil structure,

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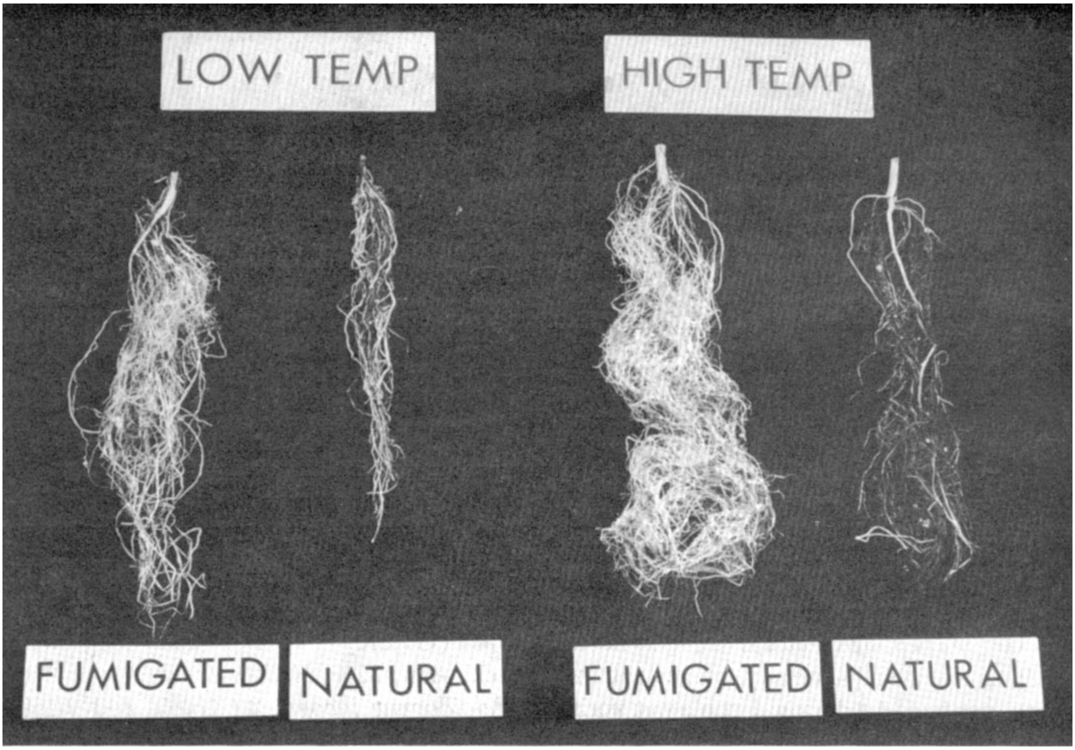

FIG. 1. The influence of pre-plant methyl bromide fumigation and soil temperature on cotton root growth.

fertility, *p*H, herbicides, and unfavorable environmental conditions. The present study was an investigation of the interaction of soilborne microorganisms and nematodes in cotton stunt.

MATERIALS AND METHODS

Two south Georgia commercial fields with histories of cotton stunt were selected for study. Soil from each field was mixed with vermiculite (3 parts field soil: 1 part vermiculite) and placed in 15-cm diameter plastic pots. Thirty pots of each soil were fumigated under plastic with DOWFUME MC-2® (Dow Chemical Co., Midland, Michigan) methyl bromide at 454g/1.4m^2 (1 lb/15 ft.^{2}) and 30 were left untreated. Three weeks after methyl bromide treatment, Ceresan-treated cotton (*Gossypium hirsutum* L. var. 'Carolina Queen') seed were sown in all pots. Two weeks later 15 pots of each soil and treatment were plunged to the soil level in sand in plastic containers and immersed to the soil level in constant temperature tanks maintained at 25 ± 2 C. Fifteen pots of each soil and treatment were placed in similar tanks maintained at 18 ± 2 C. After six weeks the plants were removed and observed for symptoms and growth characteristics. The roots were washed free of soil, cut into 2.5 cm segments, surface sterilized 1–2 min in 0.525% sodium hypochlorite, and ten randomly selected sections from each root system plated on 2% water agar for fungus assay. Soil was assayed for *Pythium* spp. using a modified Kerr's dilution plate technique (7) and for nematodes with a modified centrifugal-flotation technique (8).

TABLE 1. Comparison of cotton growth and fungi isolated from roots after 60 days in treated or non-treated soils at two soil temperatures.

Soil	Temp. (C)	Methyl bromide 454 g/1.4 m² (1 lb/15 ft²)	Root wt. (g)	Shoot wt. (g)	Shoot ht. (cm)	% frequency of isolation		
						Pythium	*Rhizoctonia*	*Fusarium*
Soil 1.	25	+	12.1 a[1]	12.6 a	23.5 a	0 a	0 a	2 a
	18	+	5.3 b	6.9 b	18.1 b	0 a	0 a	0 a
	25	CK	3.6 c	8.9 c	20.1 c	1 a	1 a	20 b
	18	CK	1.7 d	3.6 d	12.6 d	8 b	3 b	58 c
Soil 2.	25	+	5.6 a	7.6 a	20.4 a	0 a	0 a	0 a
	18	+	2.9 b	3.5 b	14.0 b	0 a	0 a	0 a
	25	CK	4.8 a	7.4 a	18.1 c	5 a	0 a	18 b
	18	CK	0.8 c	1.9 c	9.7 d	32 b	0 a	46 c

[1] Column means with the same letter are not significantly different ($P = 0.05$) according to Duncan's Multiple Range Test.

One of the previously mentioned fields (Table 1, Soil 2) was selected for study of cotton stunt and population dynamics of nematodes and soil fungi following nematicidal and fungicidal soil treatment. Twenty-four plots were established in a randomized complete block design with six replicate blocks and four treatments: (i) fungicide 67.2 kg/ha (60 lb/A) *Dexon*, p-dimethylaminobenzenediazo sodium sulphonate 35% WP, and 33.6 kg/ha (30 lb/A) *Terraclor*, pentachloronitrobenzene 75% WP); (ii) nematicide 373 liters/ha (40 gal/A), DD, 1,2-dichloropropane, 1,3-dichloropropene), (iii) combination of the fungicide and nematicide at the above rates; and (iv) control with no chemical. The fungicide was broadcast and immediately rotary-tilled to a depth of 15 cm. The nematicide was injected to a soil depth of 15–20 cm with an 11-shank applicator. Each plot consisted of four 15.2-m (50-ft) rows and data were taken from the center two rows. Three weeks after soil treatment, the plots were planted with Pennington Greencoat®-treated cotton (var. 'Carolina Queen') at 12.3 kg/ha (11 lb/A). Standard cultural practices for the southeastern cotton belt were used and the crop was machine-harvested. Soil samples were assayed for *Pythium* spp. and nematodes prior to treatment and at intervals during the growing season. Data were taken on seedling survival, plant growth and yield of seed cotton.

RESULTS

GREENHOUSE STUDY: Fumigation significantly improved root and shoot growth at 18 C in soils from both fields (Table 1). A similar response occurred with one soil at 25 C, however, the difference in the other soil

TABLE 2. Growth and yield of cotton following fungicidal and nematicidal soil. treatment.

Treatment	Stand count per 30.5 m row (100 ft)	Top height (cm)	Seed cotton per plot row	
			kg/30.5 m	(lb/100 ft)
Check	338 a[1]	46 a	6.49	(14.3) a
Fungicide[2]	218 a	35 a	4.63	(10.2) b
Nematicide[3]	369 a	65 b	8.58	(18.9) c
Nematicide & Fungicide	339 a	46 a	6.53	(14.4) a

[1] Column means with the same letter are not significantly different ($P = 0.05$) by Duncan's Multiple Range Test.
[2] 67.2 kg/ha (60 lb/A) *Dexon* (P-dimethylaminobenzenediazo sodium sulphonate) 35% WP and 33.6 kg/ha (30 lb/A) *Terraclor* (pentachloronitrobenzene) 75% WP.
[3] 373.4 liter/ha (40 gal/A) *DD* (1,2-dichloropropane and 1,3-dichloropropene).

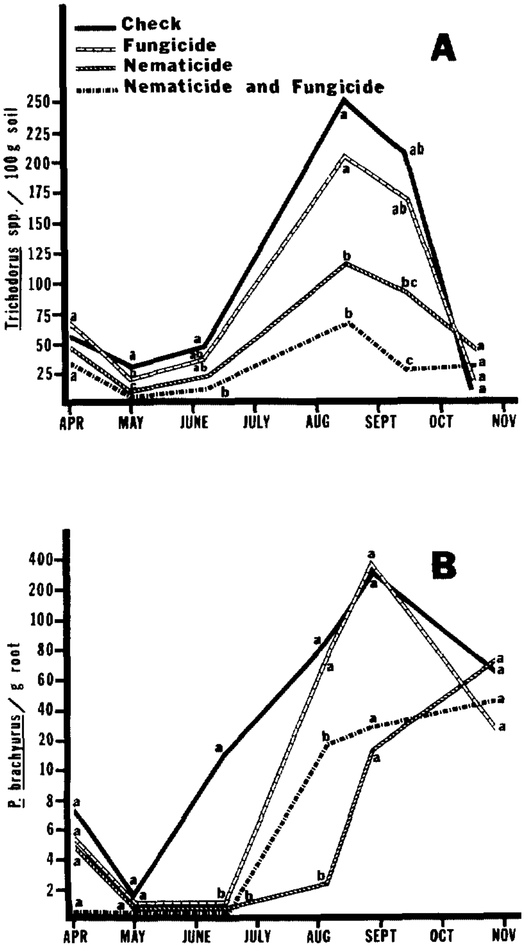

FIG. 2. Seasonal population dynamics of nematodes exposed to pre-plant fungicide or nematicide (or both). **A.** Mixed population of *Trichodorus porosus* and *T. christiei*; **B.** *Pratylenchus brachyurus.* April population density based on *P. brachyurus* per 100 g soil. (Note: In A and B, population means on a given date followed by the same letter are not significantly different, P = 0.05).

was restricted to shoot height. Plants grown in non-treated soil were stunted less at 25 C than at 18 C. The root systems of plants grown in non-fumigated soil were coarser and were extensively necrotic (Fig. 1).

Pythium irregulare and *Fusarium* spp. were isolated from cotton roots in both soils (Table 1). *R. solani* was found only in a few roots grown in one of the soils. Significantly more *P. irregulare, R. solani,* and *Fusarium* spp. were isolated from roots of plants grown in non-treated soil maintained at the lower temperature than from roots grown under any of the other treatments. *P. brachyurus, H. multicinctus* and *Criconemoides* spp. were recovered from both of the non-treated soils maintained at both temperatures. A mixed population of *T. christiei* and *T. porosus* was recovered from non-treated Soil 2 (Table 1) maintained at both temperatures.

FIELD STUDY: The nematicide treatment significantly increased vegetative growth and yield (Table 2). The fungicide treatment was phytotoxic and reduced yield. The combination of the fungicide and nematicide did not affect growth or yield and none of the treatments affected seedling survival. Populations of *Pythium* spp. were low during the first part of the growing season and no data are presented.

Nematode population dynamics were significantly affected by soil fumigation and time of growing season the samples were taken (Fig. 2). *Pratylenchus brachyurus* and the *Trichodorus* spp. complex were the only plant-parasitic nematodes uniformly distributed enough in the experimental site for analysis of nematode control by the various soil treatments. The population density of *Trichodorus* spp. decreased prior to planting, increased following seedling emergence, and reached a maximum in August (Fig. 2). After this period, when very little plant growth was evident, the populations decreased markedly. Nematicide treatment alone and in combination with the fungicide significantly reduced the *Trichodorus* spp. population below the check throughout most of the growing season. The only population density difference between the check and the fungicide treatment was evident several weeks after planting, when the latter was lower. Regardless of treatment the population levels were not significantly different at harvest.

The population dynamics of *P. brachyurus* in the control and fungicide plots were generally similar to those of *Trichodorus* spp., except that the population increase began later and had not declined as much at the final sample date. *Pratylenchus brachurus* populations in the fumigated plots did not increase until considerably later and never began to decline during the experiment. From mid-August through harvest the population densities of *P. brachyurus* which received the various treatments were not significantly different.

DISCUSSION

The survey of stunt-affected fields showed that various plant-parasitic nematodes and soil-borne fungi are often associated with stunted cotton plants. Unfortunately no single organism was consistently associated with this disease. The growth responses from soil fumigation in greenhouse tests indicated biotic factors play a major role in cotton stunt in some locations. Increased stunting at 18 C agrees with field observations that the problem is more severe in years with suboptimum temperatures in the early part of the growing season. Christiansen (6) found that low temperature alone during germination can cause stunting of seedlings, and it is known that low temperature favors damage caused by various soil-borne pathogens (10).

The growth and yield responses resulting from field application of a nematicide also indicated that biotic factors are involved in cotton stunt. *P. brachyurus* alone or with the *Trichodorus* spp. should be considered as potential primary causal agents in this particular location. The significantly lower nematode populations in the plots treated with the fungicide were most likely caused by an indirect influence of the phytotoxicity of the treatment and not by any direct toxic action on the nematodes. The fungicide treatment severely restricted root growth and Seinhorst (12) has shown that the equilibrium density of nematode populations is directly dependent on the available food supply. *Trichodorus* spp. recolonized fumigated soil and attained its maximum population density earlier than *P. brachyurus*. Failure of the nematicide treatment to significantly reduce the final nematode population densities indicates that the treatment would be effective for only one growing season. The *P. brachyurus* population probably decreased after harvest to a level similar to the initial density.

Although these results indicate that nematodes and soil-borne fungi may cause cotton stunt in certain fields, we must emphasize that different factors may be involved at other locations. Pathogenicity tests with specific microorganisms and combinations of these with each other under various environmental conditions are needed to determine their exact role in the cotton stunt disease.

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