Effect of Soil Treatment, Soil Temperature, and Plant Age on Pythium Root Rot of Cotton

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ABSTRACT

Methyl bromide or sodium-*p*-(dimethylamino)benzenediazosulfonate (Dexon) treatment of soil, collected from a problem field where stunting and root rot were present, stimulated cotton growth in plant growth chambers. A greater growth response occurred with a warm-cold-cool temperature regime than with a warm-cold-warm regime. *Pythium debaryanum* and *P. irregulare* were isolated frequently from necrotic roots in untreated soil. Pentachloronitrobenzene (Terraclor) increased root and shoot growth at the higher temperature regime, however, indicating that other members of the soil microflora were involved in stunting. Both *P. debaryanum* and *P. irregulare* decayed young secondary roots, and reduced plant height at day-night temperatures of 23 and 13 C in artificially infested soil. *Pythium irregulare* caused root necrosis and retarded shoot growth at constant temperatures of 15 and 19 C, but not from 23 to 31 C. Root rot was evident on plants 10, 20, and 30 days old at 18 C; however, disease severity generally decreased as plant age increased. Although *Pythium* spp. may cause root rot of established plants, their role in stunting in the field is probably confined to the early portion of the growing season, as soil temperatures unfavorable for disease development occur during the summer, and host resistance increases with age.

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Pythium spp. have been regarded primarily as seedling disease pathogens of cotton (2, 4). Consequently, their ability to cause root rot in older plants has received little attention. Arndt (1) demonstrated that *P. ultimum* Trow caused root necrosis and stunting of cotton plants at 24 and 27 C, and that 6-day-old plants were more susceptible than were 12-day-old plants. Spencer & Cooper (8) reported that *P. ultimum* infected roots of 28-day-old plants, but that younger plants were more susceptible. Seedling disease fungi, including *Pythium* spp., have been associated with root damage in established plants growing in field soils (3, 6, 9).

Since 1966, we have surveyed ca. 100 problem cotton fields throughout Georgia, many of which had stunted plants due to necrosis of the taproots and lateral roots. The predominant fungi isolated from affected roots were *P. debaryanum* Hesse, *P. irregulare* Buis., *P. ultimum, Fusarium* spp., and *Rhizoctonia solani* Kuehn. Although *Fusarium* spp. were associated with necrotic roots more often than other fungi, their importance in stunting is doubtful, inasmuch as they tend to be weakly pathogenic to cotton seedlings (4). Therefore, we attempted to determine the role of *Pythium* spp. in causing root necrosis and subsequent stunting of cotton plants along with factors affecting disease development, as these fungi were isolated frequently from roots growing in problem field soils which were maintained in a controlled environment (3). Initial investigations involved the use of selected chemical treatments of a soil from a field where Pythium root rot was suspected, followed by pathogenicity tests and studies to evaluate the influence of soil temperature and plant age on severity of root rot. Portions of the work have been published in preliminary reports (5, 7).

MATERIALS AND METHODS.–In all tests, acid-delinted seed (*Gossypium hirsutum* L. 'Coker 201') treated with 2.8% Methylmercury 2,3-dihydroxyproplymercaptide and 0.62% methylmercury acetate (2.25% Hg) (Ceresan L) at the rate of 1.3 g/kg were planted four/container 3.8 cm deep and thinned to one plant/container 10 days later. Treatments were replicated 10 times, and most studies were run at least twice. Where indicated, tests were carried out in Percival Model PGW 108 growth chambers with light intensity of 5,000 ft-c. Data were taken on shoot height, fresh root weight, and frequency of root infection. Isolations were made by excising 10 young root sections 2.5 cm long from each plant. After a 2-min wash in tap water, the sections were surface-sterilized in a 0.525% aqueous solution of sodium hypochlorite for 2 min and plated on 2% water agar or cornmeal agar supplemented with 100 ppm streptomycin sulfate.

RESULTS.–*Effect of chemical treatment of field soil.*–Soil was collected from a field in Washington County, Ga., where cotton was severely stunted and a Pythium root rot problem was suspected. The soil was screened to remove large debris and mixed 5:1 (v/v) with sterile sand. The following chemical treatments were applied to 41-kg soil lots: (i) sodium-*p*-(dimethylamino)benzenediazosulfonate (Dexon 35% WP), 35 g; (ii) methyl bromide (Dowfume), 454 g; (iii) pentachloronitrobenzene (PCNB) (Terraclor 75% WP), 114 g; (iv) Dexon and PCNB at the previous rates. Methyl bromide was applied under a 4-mil polyethylene cover which was removed after 24 hr. The fungicides were incorporated into the soil in dry form for 5 min in a cement mixer. Treated soils were kept at room temperature for 3 weeks prior to planting. Plastic pots (15 cm top diam) filled with the variously treated soils were placed in each of two growth chambers which were programmed on an alternating 12-hr temperature and light cycle. For 15 days after planting, temperatures were 28 (light) and 20 C (dark) in both chambers, and 20 (light) and 14 C (dark) during the following 17 days. After the initial 32 days, one chamber was adjusted to 26 (light) and 14 C (dark), and the other set at 28 (light) and 20 C (dark). Tests were terminated 8-9 weeks after planting.

Treatment with methyl bromide and Dexon significantly improved root and shoot growth over plants growing in untreated soil at both temperature

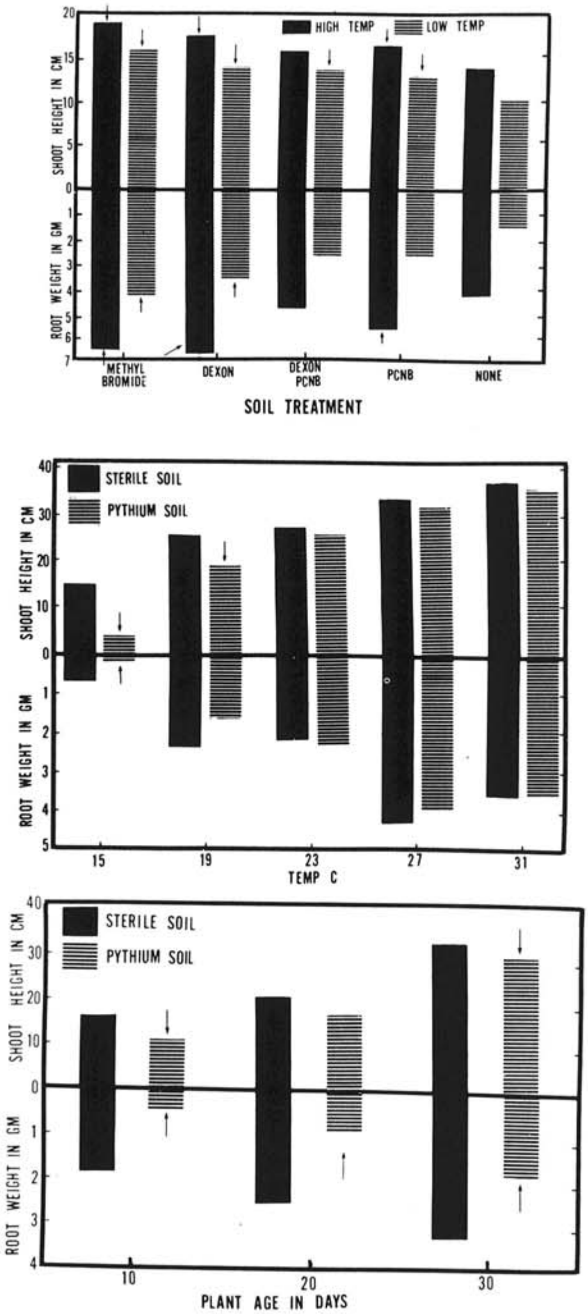

Fig. 1-3. 1) Effect of two day-night temperature regimes (high, 28 and 20 C; low, 26 and 14 C) and various chemical soil treatments on root and shoot growth of cotton in a problem field soil. Chemical treatment rates per 41 kg of soil were methyl bromide, 454 g under a 4-mil tarp; Dexon (35% WP), 35 g; pentachloronitrobenzene (PCNB) (75% WP), 114 g; and Dexon-PCNB at previous rates. Arrows indicate growth means in treated soils which are significantly different from those obtained in untreated soil according to Duncan's new multiple range test at the .05 level. **2)** Influence of various constant temperatures on cotton root and shoot growth in sterile soil and soil infested with *Pythium irregulare*. Arrows indicate significantly different growth means between plants grown in the two soils according to Duncan's new multiple range test at the .05 level. **3)** Effect of plant age on root and shoot growth of cotton at 18 C in sterile soil and soil infested with *Pythium irregulare*. Arrows indicate significantly different growth mean between plants grown in the two soils according to Duncan's new multiple range test at the .05 level.

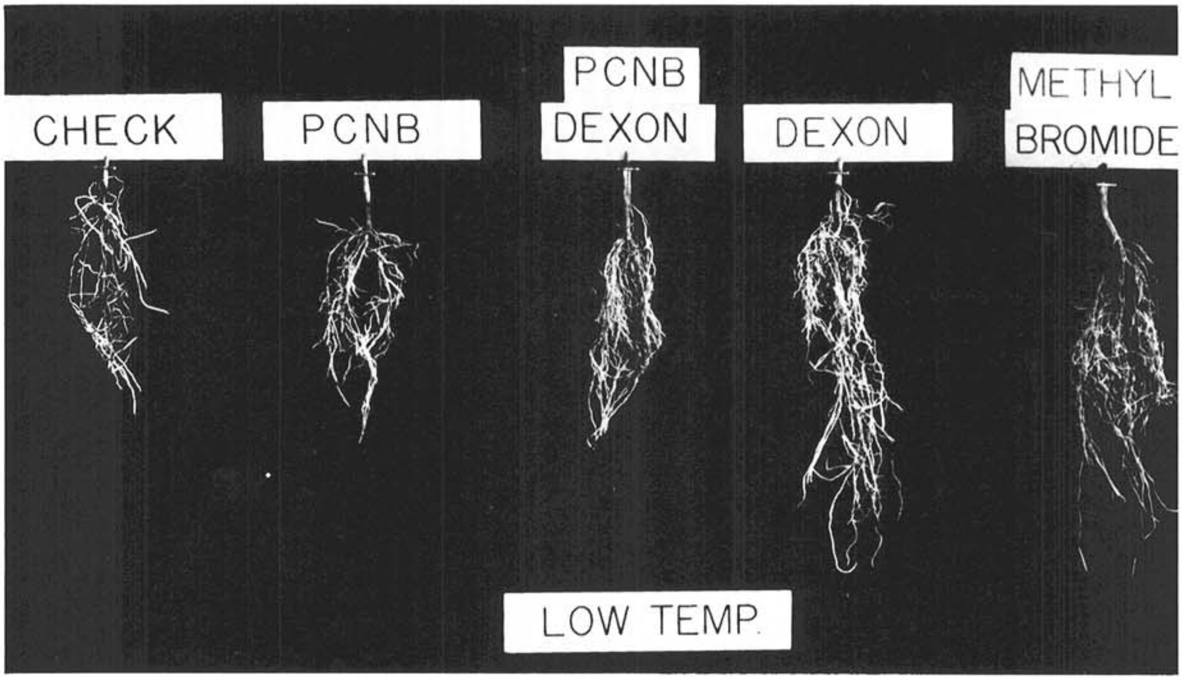

Fig. 4. Effect of various chemical soil treatments at day-night temperatures of 26 and 14 C on severity of root rot of cotton in a problem field soil.

regimes (Fig. 1). Response of roots and shoots to methyl bromide application was greater at the low regime (warm-cold-cool), however, where root and shoot growth were increased 150 and 67% over the check, respectively. At the high temperature regime (warm-cold-warm), root growth was improved 79%, and shoot height, 39%. Similar results were obtained when Dexon was used. The PCNB treatment increased root and shoot growth significantly over the check at the higher temperature, but improved only shoot height at the lower temperature. Plant growth responses were variable in soil treated with the Dexon-PCNB combination due to phytotoxicity. Root weights of plants from this treatment were lower than when Dexon was used alone, and were not significantly different from the check. At the low temperature, shoot height was increased significantly over the check; however, differences were not evident at the high temperature.

Severe root necrosis occurred in untreated soil, but was reduced when soil was treated with Dexon or methyl bromide (Fig. 4). Although *Fusarium* spp., *P. debaryanum, P. irregulare,* and *R. solani* were isolated from root lesions most often, only *Pythium* spp. were associated consistently with stunted plants. At the low temperature, frequency of isolation of *Pythium* spp. from root sections was: check, 64%; PCNB, 18%; Dexon, 2%; and both methyl bromide and the Dexon-PCNB combination, 0%. Results at the high temperature were: check, 42%; PCNB, 24%; Dexon, 15%; Dexon-PCNB, 2%; and methyl bromide, 0%.

Pathogenicity, plant age, and temperature studies.—Pathogenicity tests were carried out with *P. debaryanum* and *P. irregulare*, which were isolated from roots of stunted cotton plants. Since both isolates caused similar damage, only *P. irregulare* was used in subsequent temperature and plant age studies. Inoculum was grown in a moist sand-cornmeal medium (90:10, v/v) in 1-liter jars or in 2.8-liter Fernbach flasks for 14-18 days at room temperature. Thoroughly mixed inoculum was incorporated into a fumigated (methyl bromide 454 g/m^3) soil-sand-vermiculite mix (3:1:1, v/v) at the rate of 60 g/kg of soil mix by processing it for 3-4 min in a cement mixer. Tests were conducted in 15-cm (top diam) plastic pots which were placed in a plant growth chamber set at 26-27 C for 10 days after planting, then adjusted to a 12-hr day-night regime of 23 and 13 C for the remaining 6 weeks of the study.

Both *P. debaryanum* and *P. irregulare* caused necrosis of young secondary roots, and significantly stunted plant growth at the 23-13 C day-night temperatures. Root weight and shoot height of plants growing in infested soil were reduced 35-40% when compared with plants grown in fumigated soil. Each species was isolated from 50 to 60% of the root sections selected at random from plants grown in infested soil, and was obtained consistently from lesions.

The effect of temperature on root rot development was determined in 3.8-liter metal cans immersed in water bath tanks which were maintained at 15, 19, 23, 27, and 31 C. To prevent damping-off due to *P. irregulare*, the cans were kept in a large water bath at 27-29 C for 10 days after planting, and were then placed into smaller tanks at the designated temperatures for 7 weeks.

Optimum temperature for root rot caused by *P. irregulare* was 15 C, where both root and shoot growth were reduced significantly (Fig. 2). Although only shoot height was decreased significantly at 19 C, the roots were discolored and lesions were evident. Plant growth was not significantly affected, and root rot was not severe in the 23- to 31-C range.

Plant age studies were conducted in growth chambers adjusted to 27-29 C initially, and to 18 C when plants reached the desired age. A seeding schedule was established so that groups of plants were 10, 20, or 30 days of age simultaneously when the temperature was reduced to 18 C. Plants received 12 hr of light daily. Tests were terminated 4 weeks after the temperature was set at 18 C.

Pythium irregulare caused root rot in plants 10, 20, and 30 days old. Root weights were reduced significantly in all age groups (Fig. 3). Shoot heights were decreased significantly in the 10- and 30-day-old plants, but not in the 20-day-old group. Intensity of root rot generally decreased as plant age increased.

DISCUSSION.–Increased plant growth, associated with chemical treatment of soil from a problem field, revealed that soil-borne root pathogens are involved in cotton stunt in certain locations. Improved plant growth and the reduction of root rot in soil treated with Dexon suggested that *Pythium* spp. were involved. Methyl bromide and Dexon-induced growth responses were greatest at the low temperature regime, which is also favorable for Pythium root rot development. However, growth stimulation from methyl bromide fumigation and PCNB treatment at the higher temperature regime suggested the role of other organisms. Bird et al. (3) obtained a similar cotton growth response with methyl bromide fumigation of soils collected from two problem fields. Increased growth associated with PCNB suggested that *R. solani* may also play a role in the root rot complex, since other workers (2, 6, 9) have reported that it may attack cotton roots. We were unable to detect the fungus consistently in necrotic roots, but did observe decreased frequency of infection by *Pythium* spp. in soil treated with PCNB.

Our studies show that both *P. debaryanum* and *P. irregulare* can cause severe root rot of plants which have developed beyond the seedling stage. Root necrosis and stunting are affected greatly by soil temperature, and to a lesser degree, by plant age. Although root infection occurred above 19 C, plants were not stunted, indicating that symptom expression is dependent upon a low temperature stress on the host. Root rot severity generally decreased as plants matured. Arndt (1) has shown similar effects of soil temperature and plant age with root rot of cotton caused by *P. ultimum*.

The degree of root rot was not always correlated with reductions in shoot height, as was evident in the 20-day-old plants in the age study. We minimized variation by selecting seedlings of uniform height during thinning 10 days after planting. Nevertheless, considerable differences occurred in the subsequent growth rates of individual plants in the treatment.

The role of *Pythium* spp. in causing cotton stunt in the field probably occurs during the first 2 months after planting. Both increasing soil temperatures and plant maturity are likely to limit disease development during the remainder of the growing season. However, expression of symptoms could persist throughout the summer should young taproots and lateral roots be severely damaged (9).

LITERATURE CITED

1. ARNDT, C. H. 1943. Pythium ultimum and the damping-off of cotton seedlings. Phytopathology 33:607-611.
2. ARNDT, C. H. 1957. Temperature as a factor in the infection of cotton seedlings by ten pathogens. Plant Dis. Reptr. Suppl. 246:63-84.
3. BIRD, G. W., S. M. MC CARTER, & R. W. RONCADORI. 1971. Role of nematodes and soil-borne fungi in cotton stunt. J. Nematol. 3:17-22.
4. FULTON, N. D., & KATHARINA BOLLENBACHER. 1959. Pathogenicity of fungi isolated from diseased cotton seedlings. Phytopathology 49:684-689.
5. MC CARTER, S. M., & R. W. RONCADORI. 1970. Influence of plant age and temperature on root rot of cotton caused by Pythium irregulare. Phytopathology 60:585 (Abstr.).
6. NEAL, D. C. 1942. Rhizoctonia infection of cotton and symptoms accompanying the disease in plants beyond the seedling stage. Phytopathology 32:641-642.
7. RONCADORI, R. W., F. F. HENDRIX, JR., & W. M. POWELL. 1967. Fungi associated with cotton root necrosis. Phytopathology 57:827 (Abstr.).
8. SPENCER, J. A., & W. E. COOPER. 1967. Pathogenesis of cotton (Gossypium hirsutum) by Pythium species: zoospore and mycelium attraction and infectivity. Phytopathology 57:1332-1338.
9. STEWART, R. B., & M. D. WHITEHEAD. 1955. Nubroot – the expression of seedling disease in the mature cotton and flax plant. Phytopathology 45:413-416.