Populations of Fungi in Soil After Chemigation with Chlorothalonil and Tebuconazole via Center-Pivot Irrigation

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ABSTRACT

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Chlorothalonil and tebuconazole were applied to peanut (*Arachis hypogaea*) through a center-pivot irrigation system (chemigation), a pivot-mounted underslung boom, or ground sprays. Populations of *Rhizoctonia solani* AG-4, *R. zeae*, and *Sclerotium rolfsii* in soil at midseason and at digging were variable and were not influenced significantly by chemical treatment or application method. Chemigation with tebuconazole, but not with chlorothalonil, reduced populations of total fungi in soil at digging, and in one test all applications of tebuconazole reduced populations of binucleate *Rhizoctonia* CAG-3. Populations of other binucleate *Rhizoctonia* spp. were not affected by treatments with either chemical. Rhizoctonia limb rot was correlated significantly with populations of *R. solani* AG-4 in soil in only one of four experiments.

Fungicides to control foliar diseases in peanut (*Arachis hypogaea* L.) may be applied via ground sprays or overhead irrigation water (1,4,5) or through a pivot-mounted underslung boom (Pivot Agrichemical Spray System [PASS]). When fungicides are applied in high volumes of water through center-pivot irrigation, the chemicals are distributed throughout the canopy and into the soil (1). With chemigation, less than 10% of chlorothalonil is retained on leaves (10). In previous research in greenhouse and field microplots, populations of soil fungi usually did not differ when either chlorothalonil or diniconazole was applied with a hand sprayer (9.4 ml/m^2) or with a sprinkler can (4 L/m^2) (18). However, chlorothalonil reduced the severity of pod rot in soil infested with *Sclerotium rolfsii* Sacc., and both fungicides usually reduced populations of *Rhizoctonia solani* Kühn anastomosis group 4 (AG-4) and the number of lesions on pods, pegs, and stems of peanut. Chlorothalonil has been applied successfully through irrigation water to control belly rot induced by *R. solani* AG-4 in cucumber (*Cucumis sativus* L.) fruit (20,21).

We have reported (5,6) the effects of chemigation of chlorothalonil and tebuconazole on late leaf spot of peanut, caused by *Cercosporidium personatum* (Berk. & M.A. Curtis) Deighton, in Georgia. This research was initiated as a corollary to determine if chlorothalonil and tebuconazole applied to peanut through center-pivot irrigation systems would affect populations of *R. solani* AG-4, *S. rolfsii*, other soilborne basidiomycetes, and saprophytic fungi in soil.

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MATERIALS AND METHODS

Field experiments. Research was initiated in 1987 in a field of Pelham loamy sand (thermic Arenic Paleudults) in Tift County near Tifton, Georgia. The experiment with chlorothalonil was contained in one quadrant (0.15 ha) of a single-tower center-pivot irrigation system and was repeated in 1988 in an adjacent quadrant. The tests followed a rotation of tobacco and onions in 1986 and of sweet corn and lettuce in 1985. The land was moldboard-plowed 20–25 cm deep, disked, and bedded. The peanut cultivar Florunner was planted in single rows 0.91 m apart at 123 kg/ha of seed in 1987 and 112 kg/ha in 1988. Planting date was 18 May both years, and standard management recommendations of the Georgia Cooperative Extension Service were followed (8). No tractor traffic was allowed in the field after peanut branches closed the rows except where specified. Plots were single beds (7.6 × 1.8 m in 1987 and 6.1 × 1.8 m in 1988), with two rows per bed and with two border rows and 2.1-m alleys between plots. A completely randomized design with four replications was used.

Treatments were: 1) nonsprayed, no tractor traffic (control); 2) chemigation (fungicide injected into center-pivot system), no tractor traffic; 3) chemigation, tractor traffic; 4) fungicide applied via PASS, no tractor traffic; and 5) ground spray. Chlorothalonil (Bravo 720, 1,255 g a.i./ha) was applied on a 14-day schedule beginning 5 wk after planting, for a total of seven applications. All fungicide applied via chemigation or PASS was diluted with water (1:3.7, fungicide:water). Chemigation treatments were applied in 17.8 kl of water per hectare via whirl jet sprinklers and in 1.7 kl of water per hectare via PASS. To minimize the effects of additional water on chemigated plots, the entire field received 127 kl of water per hectare the evening before each application. During chemigations, plots not being treated were covered with either plastic sheets or elevated fiberglass shelters. A Ford 2910 tractor was used to travel the trafficked plots afterward, including the ground-sprayed plots. In sampled plots, tractor tires had traveled on both sides of the 1.8-m beds. Ground sprays were applied with a CO_2-pressurized backpack sprayer with three D2-13 nozzles per row delivering 124.4 L of spray per hectare at 345 kPa.

Similar experiments with tebuconazole were begun in 1987 in one quadrant (0.15 ha) of an adjacent single-tower center-pivot irrigation system in the same field and were repeated in 1988 in an adjacent quadrant. The tests followed soybean (*Glycine max* (L.) Merr.) and fallow in 1987 and rye (*Secale cereale* L.) in 1988.

Tebuconazole (Folicur 1.2 EC, 252 g a.i./ha) was applied on a 14-day schedule beginning 5 wk after planting, for a total of seven applications. Treatments were: 1) nonsprayed, no tractor traffic (control); 2) chemigation with water as diluent (1:3.7, fungicide:water), no tractor traffic; 3) chemigation with water as diluent (1:3.7, fungicide:water), tractor traffic; 4) chemigation with 11N Sunspray oil as diluent (1:1.7, fungicide:oil), no tractor traffic; and 5) ground spray. Chemigation treatments were applied in 0.25 cm of water via impact sprinklers; the oil-diluted treatment was agitated mechanically to maintain a uniform suspension.

Peanuts in both tests were dug 28 September 1987 and 5 October 1988 and harvested 5–7 days later. Rhizoctonia limb rot was rated immediately after digging by visually estimating the percentage of branches and leaves infected in each of six 0.6-m areas selected at

random in each plot.

In 1987, soil was collected on 6 June (before applications), 21 July (after three applications), and 6 October (after seven applications and 1 wk after digging). In 1988, soil was collected on 16 June (before applications), 15 August (after four applications), and 29 September (after seven applications and just before digging). Ten cores, 2.5 cm in diameter and 8 cm deep, were removed 15 cm from the row in each plot and composited. Soil was stored in a cold room at 5–7 C and processed in 1–7 wk. Soil was assayed on TABA (17) with a multiple-pellet soil sampler (7) for *R. solani* and other basidiomycetes, on PARP agar (9) for *Pythium* spp., on modified PCNB agar (11) for *Fusarium* spp., and on OAES agar (23) for saprophytic fungi.

In 1987, sclerotia of *S. rolfsii* were produced on field soil in a greenhouse (4); wheat bran was used as inoculum instead of oats. Sclerotia were stored dry in vials at 25–35 C until used. Viability was determined by surface-disinfesting sclerotia for 3 min in 0.25% NaOCl, then incubating them on water agar at 23–30 C. Packets (5 × 6 cm, made of plastic mesh fastened with staples) of 50 viable sclerotia were prepared, and two were buried, after cultivation, on 17 June in the center of one row in all plots except those receiving chemigation plus tractor traffic. Packets were laid horizontal to the row, one 2 cm and the other 6 cm deep. The packets were dug on 23 September and rinsed in tap water, and the sclerotia were incubated on oxalate-gallate agar (2) to determine viability.

In 1988, a separate experiment was conducted in a grower's 55-ha field of peanut under one overhead center-pivot irrigation system in Randolph County. The site had a history of southern stem rot on peanut in 1986 and had been planted with winter rye-soybean-winter rye in 1987 before being replanted to peanut in 1988. Chlorothalonil was applied by chemigation (2.5 or 3.8 kg a.i./ha) to nonreplicated, triangular sections of the field on 11 July and 1 and 19 August, both with and without preplant incorporation of chlorothalonil (1.25 kg a.i./ha) on 30 April. The grower mixed the chlorothalonil with preemergence herbicide and incorporated the pesticides 8–12 cm deep with a disk harrow. In one section, carboxin was applied by chemigation (1.26 kg a.i./ha) on 30 July with a preplant incorporation of chlorothalonil. All sections, including the nonchemigated control, were given chlorothalonil by conventional ground sprays every 10–14 days from 16 May through 14 September.

Soil samples were collected on 11 July, before chemigation. Five samples (each a composite of 10 cores 7–10 cm deep) were collected from each section to receive chemigation, and 10 samples were collected from the control. On 6 September, cores were collected in a similar manner and, in addition, 30–40 ml of soil was collected with a hand trowel 2–3 cm deep immediately adjacent to each hole where a soil core was taken. The surface soil samples were composited and paired with each soil core sample in the statistical analysis. All samples were assayed for *R. solani* and binucleate *Rhizoctonia* spp. on TABA. The remaining moist field soil in each sample was assayed for *S. rolfsii* by allowing the soil to imbibe a 1% methanol solution (13). Closed trays of soil were incubated under fluorescent light in alternating 12 hr light/12 hr dark for 4 days at 22–25 C, and colonies of *S. rolfsii* per 100 g of soil were counted.

After digging and plant inversion (26 and 27 September), symptoms of limb rot or white mold were recorded. The number of diseased plants in two rows 30 m long were counted in each of five randomly selected areas in each treatment, and the percentage of diseased plants was calculated. Each treatment area was harvested separately by the grower and the yield determined.

Greenhouse experiments. For simulation of applications of fungicides by chemigation, soils were treated with fungicides applied with a sprinkler can (19). Tifton loamy sand was treated with aerated steam (65 C for 30 min), mixed with fertilizer (13 mg N, 27 mg K, 40 mg P per kilogram of soil), and infested with *R. solani* AG-4 isolate 109 (from peanut seed) or noninfested. Inoculum was grown 2–3 wk on 3% cornmeal sand (w/w) and mixed with soil (1:760, v/v) in a concrete mixer. Peanut cultivar Florunner was planted (four replications) in 2-L plastic cans (five seeds per pot), and soil was drenched with tebuconazole (0.165 mg a.i./L of soil) using 100 ml of a water solution per liter of soil. After 30 days, soil from each pot was mixed and assayed for *R. solani* AG-4 on TABA. Soil temperatures during the experiment ranged from a night minimum of 13–20 C to a day maximum of 22–36 C.

A second factorial experiment was conducted with different inoculum densities of *R. solani* AG-4 and chlorothalonil rates, with or without peanut. Inoculum was mixed with soil (1:2,467, 1:5,262, or noninfested), and 4 L of soil was placed in each pot. A randomized complete block design with three replications was used. Soil in pots was planted with peanut (five seeds per pot, 4 cm deep) or left fallow, and chlorothalonil drenches (chemigation) were applied 4 and 6 wk after planting at equivalent rates of 0, 1,268, 2,525, and 3,788 g a.i./ha. Rates were computed on the basis of surface area of soil, and drenches were applied in 0.64 cm of water (180 ml per pot, equivalent to 6.35 L/m^2). Chemigation treatments were applied over the peanut foliage, and after treatments were begun, all pots were watered with hand-held sprinkler cans (1.0–1.25 ml/cm^3 of soil) every 1–3 days, from 4–8 wk after planting.

Plants were dug 8 wk after planting, roots and hypocotyls were washed and blotted dry with paper towels, and the entire plants were weighed. Roots and hypocotyls were evaluated for symptoms of disease, and each plant was placed into one of five categories: none = <2, slight = 2–10, moderate = 11–50, severe = >50% of the tissues discolored and decayed, and dead. Soil in the top 7.5 cm of each pot was mixed individually and assayed for *R. solani* AG-4 on TABA. Soil temperatures during the experiment ranged from a night minimum of 12–22 C to a day maximum of 27–40 C in soil planted to peanut; temperatures were 1–5 C higher in fallow soil.

In all experiments, data were analyzed by general linear model statistical procedures (14). Data were transformed as necessary (square root transformations for small numbers [<100], log base 10 for large numbers [>100], and arcsin transformations for percentages [15]) for statistical analysis, but all data are reported as untransformed values. Partial correlation coefficients were determined for populations of basidiomycetes in soil and the percentage of branches infected with limb rot (15).

RESULTS

Chlorothalonil, 1987. Populations of most fungi were not influenced by applications of chlorothalonil. On 17 June, 1 day before applications were begun, there were no differences in populations of individual fungi or total fungi among plots, except that populations of *Aspergillus niger* Tiegh. were lower in control plots than in plots scheduled to receive applications of chlorothalonil. The only difference among treatments on 21 July was that populations of *Aspergillus* spp. were not detected in the control but were present in plots treated with chlorothalonil (Table 1). Populations of total fungi did not differ among treatments (*data not shown*). On 6 October, 7 days after peanuts were dug, there were no differences in populations of any fungus or of total fungi among treatments. Populations of *R. solani* AG-4 and binucleate *Rhizoctonia* spp. were low in all treatments (Table 1). Other fungi identified and included in the statistical analysis were *R. zeae* Voorhees, *Laetisaria arvalis* Burdsall, a sterile white basidiomycete (18), *Fusarium solani* (Mart.) Sacc., total *Fusarium* spp., *Pythium* spp., *Neocosmospora vasinfecta* E.F. Sm., *Trichoderma* spp., *A. niger, Aspergillus flavus* Link:Fr., total *Aspergillus* spp., *Penicillum* spp. plus *Paecilomyces* spp., *Cladosporium* spp., *Helminthosporium* spp., *Curvularia* spp., *Phoma* spp., *Mucor* spp., *Rhizopus* spp., *Zyghorhynchus* spp., total oomycetes and zygomycetes, and total fungi.

There were no significant differences among treatments in the survival of *S. rolfsii* sclerotia buried in soil. An average of 91 and 83% of sclerotia were viable 2 and 6 cm deep, respectively, 14 wk after burial.

Chlorothalonil, 1988. On 15 August, after four applications, there were no significant differences in populations of any fungi except *Fusarium* spp. (other than *F. solani*) or in total fungi. Populations of individual and total fungi (other than basidiomycetes) did not differ among treatments on 29 September, just before digging. Populations of *R. solani* AG-4 were low, and populations of binucleate *Rhizoctonia* spp. were low to moderate. Chlorothalonil applied by chemigation or ground spray, but not by PASS, reduced populations of binucleate *Rhizoctonia* CAG-2 but had no effect on populations of other basidiomycetes.

In the field experiment in Randolph County in 1988, populations of *R. solani* AG-4 and AG-2-2 were very low on 11 July (av. 0.4 and 0.3 cfu/100 g of soil, respectively) before chemigation was begun, and no other *R. solani* anastomosis group or binucleate *Rhizoctonia* sp. was detected. *S. rolfsii* was present in all areas of the field, ranging from 0.2 to 1.4 cfu/100 g of soil. On 6 September, populations of *R. solani* AG-4 averaged 2.6 and 4.8 cfu/100 g in cores 15 cm deep and surface samples, respectively, and were not significantly different. Average populations of AG-2-2, AG-2-1, CAG-2, CAG-3, CAG-4, and CAG-5 ranged from nondetectable to 1.8 cfu/100 g, and populations were significantly higher in the surface soil than in the soil cores for all except AG-2-1, CAG-2, and CAG-5. Populations of AG-4 and total *R. solani* were significantly higher in soil cores on 6 September than on 11 July, but populations of binucleate *Rhizoctonia* spp. did not differ.

Populations of *S. rolfsii* on 6 September were significantly higher in surface soil than in soil cores (2.1 vs. 0.9 cfu/100 g). Populations in soil cores on 6 July and 11 September did not differ (0.7 vs. 0.9 cfu/100 g).

Because of a lack of replication, no statistical comparison could be made among the chlorothalonil treatments. The percentage of plants with symptoms of limb rot or southern stem rot after digging ranged from 18 to 52%. The lowest incidence was in the chemigated plots and the highest incidence was in the nonchemigated control. Yields ranged from 4,200 to 5,200 kg/ha, with the numerically highest yields in the area receiving chemigations of 3.8 kg/ha of chlorothalonil on 11 July, 1 August, and 19 August.

Tebuconazole, 1987. Initial populations of *Penicillium* spp. were unevenly distributed among treatment plots, but otherwise there were no significant differences in initial populations of soil fungi among plots on 17 June, before treatments were begun. Populations of *R. solani* AG-4 and binucleate *Rhizoctonia* spp. averaged 8.0 and 0.6 cfu/100 g of oven-dried soil, respectively. On 21 July, after three applications, only a few differences were evident, including a significant reduction of *Alternaria* spp. by all methods of application (Table 2). On 6 October, 1 wk after digging, populations of total fungi in soil were reduced, compared with the control, by all application methods except chemigation plus traffic and a water diluent. All application methods reduced populations of binucleate *Rhizoctonia* CAG-3, but populations of other soil fungi were not affected (Table 2). Populations of each of the other binucleate *Rhizoctonia* spp. averaged ≤1.0 cfu/100 g of soil in each treatment.

There were no significant differences among treatments in viability of *S. rolfsii* sclerotia 14 wk after burial in soil. An average of 97 and 87% of the sclerotia buried 2 and 6 cm deep, respectively, germinated.

Tebuconazole, 1988. As in 1987, there

Table 1. Populations of fungi in oven-dried soil in peanut treated with chlorothalonil (Bravo 720, 1,255 g a.i./ha) applied through ground sprays and center-pivot irrigation water, 1987[y]

Treatment	21 July	6 October				
	Aspergillus spp. (cfu/g)	*Rhizoctonia solani* AG-4 (cfu/100 g)	Binucleate *Rhizoctonia* spp. (cfu/100 g)			
			CAG-2	CAG-3	CAG-4	CAG-5
Nonsprayed control	ND b[z]	1.4	1.4	4.3	ND	ND
Chemigation, no tractor traffic	5,950 a	2.9	ND	11.4	ND	1.4
Chemigation, tractor traffic	4,960 ab	2.9	1.4	ND	ND	1.4
Underslung boom	6,940 a	ND	ND	1.4	ND	ND
Ground spray, tractor traffic	6,940 a	ND	1.4	1.4	1.4	ND

[y] Treatments were applied 18 June; 2, 16, and 30 July; 13 and 27 August; and 8 September.
[z] Numbers in columns followed by the same letter are not significantly different according to Fisher's LSD, $P = 0.05$ (15); no letter indicates no significant difference. ND = none detected. Detection level was 1.2 cfu/100 g of soil with basidiomycetes and 992 cfu/g of soil with *Aspergillus* spp.

Table 2. Populations of fungi in oven-dried soil in peanut treated with tebuconazole (Folicur 1.2 EC, 252 g a.i./ha) applied through ground sprays and center-pivot irrigation water, 1987[y]

Treatment	21 July			6 October		
	Alternaria spp. (cfu/g)	*Pythium* spp. (cfu/g)	*Fusarium moniliforme* (cfu/g)	*Rhizoctonia solani* AG-4 (cfu/100 g)	Binucleate *Rhizoctonia* sp. CAG-3 (cfu/100 g)	Total fungi (cfu/g)
Nonsprayed control	27,200 a[z]	362 a	32 b	ND	25.3 a	93,400 a
Chemigation, no tractor traffic, water diluent	2,020 b	255 ab	ND b	1.3	4.0 b	52,400 b
Chemigation, tractor traffic, water diluent	ND b	335 a	129 a	ND	ND b	69,500 ab
Chemigation, no tractor traffic, 11N oil diluent	ND b	315 a	ND b	ND	ND b	57,200 b
Ground spray, tractor traffic	ND b	174 b	ND b	ND	1.3 b	63,800 b

[y] Treatments were applied 18 June; 2, 16, and 30 July; 13 and 27 August; and 8 September.
[z] Numbers in columns followed by the same letter are not significantly different according to Fisher's LSD, $P = 0.05$ (15); no letter indicates no significant difference. ND = none detected. Detection level was 1.3 cfu/100 g of soil with basidiomycetes, 32 cfu/g of soil with *F. moniliforme*, and 971 cfu/g of soil with *Alternaria* spp.

Table 3. Populations of fungi in oven-dried soil in peanut treated with tebuconazole (Folicur 1.2 EC, 252 g a.i./ha) applied through ground sprays and center-pivot irrigation water, 1988[x]

Treatment	15 August		29 September		
	Fusarium solani (cfu/g)	*Phoma* spp. (cfu/g)	*Rhizoctonia* solani AG-4 (cfu/100 g)	Binucleate *Rhizoctonia* spp.[y] (cfu/100 g)	Total fungi (cfu/g)
Nonsprayed control	230 b[z]	7,680 a	6.7	18.3	90,300 a
Chemigation, no tractor traffic, water diluent	820 a	5,900 ab	ND	5.0	58,600 ab
Chemigation, tractor traffic, water diluent	460 ab	ND c	ND	1.7	25,000 b
Chemigation, no tractor traffic, 11N oil diluent	460 ab	2,940 a–c	ND	ND	32,700 b
Ground spray, tractor traffic	690 a	980 bc	ND	ND	52,800 ab

[x] Treatments were applied 22 June; 6 and 20 July; 3, 16, and 30 August; and 13 September.
[y] CAG-3, CAG-4, and CAG-5 combined.
[z] Numbers in columns followed by the same letter are not significantly different according to Fisher's LSD, $P = 0.05$ (15); no letter indicates no significant differences. ND = none detected. Detection level was 1.6 cfu/100 g of soil with basidiomycetes and 961 cfu/g of soil with *Phoma* spp.

Table 4. Inoculum densities of *Rhizoctonia solani* AG-4 in oven-dried soil planted to peanut or fallow, then drenched with chlorothalonil in a greenhouse

	Colonies (cfu/100 g)[x]			
	Extra large	Large	Small	Total
Inoculum level (IL)				
High	13 a[y]	34 a	81 a	128 a
Low	6 b	32 a	84 a	122 a
None	ND c	ND b	ND b	ND b
Chlorothalonil, mg a.i./m^2 (C)				
0	9	24	60	93
127	9	22	52	83
252	4	22	50	76
379	4	19	58	81
Crop				
Peanut	8 a	28 a	61 a	97 a
Fallow	5 b	16 b	49 a	70 b
Comparisons of interest[z]				
IL × C	NS	NS	NS	0.05
C-linear	0.05	NS	NS	NS
C-quadratic	NS	NS	NS	NS
C-cubic	NS	NS	NS	NS

[x] After incubation for 48 hr at 26 C on TABA. Extra large, large, and small colonies were >4, <4>2, and <2 cm in diameter, respectively.
[y] Numbers in columns of inoculum levels or crops followed by the same letter are not significantly different according to Fisher's LSD, $P = 0.05$ (15). ND = none detected. Detection level was 1.3 cfu/100 g of soil.
[z] $P = 0.05$ for contrasts used to examine effects for rates of chlorothalonil. NS = no significant difference.

were no significant differences in initial populations of fungi among plots on 16 June, before applications. On 15 August, populations of *F. solani* were higher in the ground spray and chemigation with no traffic treatments than in the control, but populations of *Phoma* spp. were lower in the ground spray and chemigation plus traffic treatments than in the control. On 29 September, just before digging, populations of total fungi were lower in two of three chemigation treatments than in the control but did not differ in chemigation and ground spray (Table 3). There were no significant differences among treatments anytime during the season in populations of *R. solani* AG-4, binucleate *Rhizoctonia* spp., *Pythium* spp., or any of the other fungi identified on the selective media. Basidiomycetes were detected infrequently in soil throughout the season.

There were no significant correlations between early or midseason soil populations of *R. solani* AG-4 and the percentage of branches infected with the pathogen in any of the four field experiments in Tift County. In the 1988 experiment with chlorothalonil, there was a significant positive correlation between populations of *R. solani* AG-4 at digging and limb rot ($r = 0.64$, $P = 0.01$), but there were no significant differences in limb rot among treatments. Populations of *R. solani* AG-4 and limb rot were not correlated in the other three experiments. In both experiments with tebuconazole, limb rot was positively correlated with populations of *R. zeae* at digging, but this fungus was detected in only a few plots. In each experiment, populations of the different *R. solani* and binucleate *Rhizoctonia* spp. and *R. zeae* at different times during the season were usually low and variable and rarely correlated with one another.

Greenhouse experiments. Populations of *R. solani* AG-4 in infested soil treated with tebuconazole and in nontreated infested soil averaged 458 and 547 cfu/100 g 30 days after treatment and did not differ significantly ($P = 0.05$). No peanuts emerged in either treatment. In contrast, no *R. solani* was detected in nontreated noninfested soil. Emergence averaged 75%, and plants had no root or hypocotyl disease.

In the second experiment, drenching with chlorothalonil did not reduce total soil populations of *R. solani* AG-4 8 wk after planting, but dosage of chlorothalonil did have a significant linear effect on the number of extra large (>4 cm in diameter) colonies after 48 hr at 26 C on TABA (Table 4); colony size indicates competitive saprophytic ability (12). However, the reduction occurred only at the high inoculum level, where chlorothalonil at 127, 252, and 379 mg/m^2 reduced populations of extra large colonies to 17, 6, and 7 cfu/100 g of soil compared with 22 cfu for the control. Populations in the low inoculum level varied from four to 10 extra large colonies and did not differ significantly. In soil not treated with chlorothalonil, the percentage of extra large colonies was greater at the high than at the low inoculum level (14 vs. 3%).

There was a significant interaction of chlorothalonil dosage levels with inoculum levels of *R. solani* AG-4 on final populations of total *R. solani* AG-4, but total populations of *R. solani* AG-4 were very high at all dosages. At chlorothalonil dosages of 0, 127, 252, and 379 mg a.i./m^2, total populations of *R. solani* AG-4 were, respectively, 159, 139, 98, and 124 cfu at the high inoculum level and 124, 113, 130, and 121 at the low inoculum level. (The field rate of 1,255 g/ha is comparable to 127 mg a.i./m^2.) There was no interaction of inoculum level with crop (peanut or fallow) or of chlorothalonil dosage with crop.

Populations were very high at both high and low inoculum levels in both fallow and soil planted to peanut. Cropping with peanut increased the number of extra large (>4 cm) and large (<4>2 cm) colonies of *R. solani* AG-4 over those in fallow soil.

Few peanut plants emerged in soil infested with the high inoculum level, and emergence was 33% less with the low inoculum level than in the control. Roots and hypocotyls were injured severely (>50% discoloration and decay) on most plants in infested soil, but reductions in plant weight were much greater with the high than with the low inoculum level (Table 5). In contrast, more plants in the low inoculum level had discrete stem lesions.

Chlorothalonil dosages had a significant quadratic effect on the number of plants with severe root and hypocotyl rot and both a quadratic and a cubic effect on the number of stem lesions per plant, but differences were small. Chlorothalonil had no significant effect on the number of plants with moderate root and hypocotyl rot and total plant weight (Table 5). The lateral stems had few lesions, and the pots were not large enough to permit measurement of the effect of chlorothalonil on stems in contact with soil through a full peanut crop.

DISCUSSION

Previous research (19) showed that, compared with nontreated soil, chlorothalonil applied with a sprinkler can by hand over peanut plants in greenhouse and field microplots reduced populations of *R. solani* AG-4 in one of three experiments. In contrast, in the present experiments using center-pivot irrigation systems, populations of *R. solani* AG-4, other *R. solani* anastomosis groups, and binucleate *Rhizoctonia* spp. were low and did not differ among chlorothalonil or tebuconazole treatments. Competitive saprophytic activity may be related to inoculum potential (12), and propagules that produce large colonies may have more inoculum potential than propagules that produce small colonies. In the greenhouse, high dosages of chlorothalonil reduced the number of colonies >4 cm in diameter growing from soil pellets after 48 hr of incubation at 26 C. Rhizoctonia limb rot, caused by *R. solani* AG-4, was not reduced by chemigation with chlorothalonil but was reduced by chemigation with tebuconazole (5).

In the present experiments, limb rot disease was moderate to severe in some plots, but in only one experiment was disease severity related to populations of *R. solani* AG-4 in the top 15 cm of soil. In belly rot of cucumber, populations of *R. solani* AG-4 in soil immediately adjacent to cucumber fruits was considered to be the primary source of inoculum (21). In our research in peanut in Randolph County, populations of *R. solani* were higher in surface soil than in soil cores. It may be that only propagules of *R. solani* AG-4 in surface soil serve as inoculum to cause limb blight in peanut in naturally infested soil. Infection begins on lower branches in contact with soil (3,22), and the disease may spread rapidly (3). Factors such as irrigation frequency, temperature, relative humidity, and competitors and antagonists in soil may be related more to disease intensity than to *R. solani* AG-4 inoculum density (3).

Research by ISK Biotech Corp. showed that chlorothalonil is bound by soil and is not biologically available or subject to leaching. Mobility is low even in sandy soils (G. L. Eilrich, *personal communication*). Data on the movement of tebuconazole in soil is unavailable from the manufacturer. The small changes in populations of soil fungi among treatments in our experiments may have been related to the lack of movement of these fungicides in soil.

When peanut stems were crushed by tractor tires, isolates of CAG-3 were obtained frequently (6). We found isolates of CAG-3 in soil in all tests, but populations varied from undetectable to 31 cfu/100 g. All methods of application of tebuconazole reduced populations of CAG-3 in 1987, but populations were not correlated with limb rot. The fungus is widespread in the soils of the Georgia coastal plain, and some isolates are pathogenic on cowpea (16) and crucifers (D. R. Sumner, *unpublished*).

Tebuconazole reduced populations of total fungi at digging, but the reduction could not be attributed to any specific fungus that was identified by soil dilutions. Pod rot, caused by *S. rolfsii, R. solani*, or *Pythium* spp., was negligible in our tests, and yield increases with chemigation of both fungicides appeared to be related more to control of leaf spot control than to control of soilborne pathogens.

Fungicides were applied in the Tift County tests in volumes of water ranging from 0.12 to 17.8 kl/ha. Although differences in populations of some fungi were detected among treatments, overall there were few significant differences in populations of soil fungi related to the volume of water used. Both tebuconazole and chlorothalonil are broad-spectrum fungicides. The fact that chemigated applications of either fungicide had no more impact on populations of soil fungi than did conventional ground sprays indicates that such high-volume applications are not as disruptive of the soil mycoflora as might be hypothesized.

Table 5. Emergence, root and hypocotyl disease, stem lesions, and plant weight of peanut planted five seeds per pot and grown 8 wk in a greenhouse in soil infested with *Rhizoctonia solani* AG-4 and drenched with chlorothalonil

		Percent plants with root and hypocotyl disease[x]		Stem lesions per plant	Fresh plant weight (g)
	Emergence	Moderate	Severe		
Inoculum level (IL)					
High	1.2 c[y]	100	100 a	0.5 b	17.0 c
Low	3.2 b	98	87 b	1.0 a	55.2 b
None	4.8 a	0	0 c	0.0 c	97.8 a
Chlorothalonil, mg a.i./m^2 (C)					
0	2.8	67	67	0.3	56.4
127	3.4	67	61	0.9	54.1
252	3.0	64	55	0.4	59.8
379	3.1	67	67	0.5	56.2
Comparisons of interest[z]					
IL × C	NS	NS	NS	NS	NS
C-linear	NS	NS	NS	NS	NS
C-quadratic	NS	NS	0.05	0.05	NS
C-cubic	NS	NS	NS	0.01	NS

[x] Moderate = 11–50% and severe = >50% root and hypocotyl discoloration and decay.

[y] Numbers in columns of inoculum levels followed by the same letter are not significantly different according to Fisher's LSD, $P = 0.05$ (15).

[z] $P = 0.05$ or 0.01 for contrasts used to examine effects for rates of chlorothalonil. NS = no significant difference.

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