Host and Nonhost Effects on Soil Populations of Phytophthora parasitica var. nicotianae

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ABSTRACT

Population increases of *Phytophthora parasitica* var. *nicotianae* in soil were dependent upon pathogenesis. Populations increased rapidly when susceptible cultivars were transplanted into artificially or naturally infested soils. With a moderately resistant cultivar, populations increased more slowly. Race 0 increased to a slight extent with the highly resistant cultivar, Burley 21 × L8. Nonhost plants (tomato, pinto bean, cowpea, wheat, and fescue) had no effect on populations, and none of the plants evaluated had any effect on populations of *Pythium* spp. indigenous to the naturally infested soil. Freezing and thawing conditions of winter weather had no influence on natural populations of *P. parasitica* var. *nicotianae* or *Pythium* spp.

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Tobacco (*Nicotiana tabacum* L.) is an important cash crop in the southeastern United States. It is grown continuously for many years in some areas, but more often in rotations of various durations. Principal alternate crops include corn, soybeans, peanuts, cotton, small grains, grasses, and weed fallow. Soil-borne disease organisms often dictate the length of various rotation systems.

The black shank pathogen, *Phytophthora parasitica* (Dast.) var. *nicotianae* (Breda de Haan) Tucker, becomes well established in some fields soon after initial infestation and may persist for several years in the absence of tobacco (1, 2, 4, 8, 9, 10). Several workers (2, 8, 12) have reported that a period of 4-6 yr between tobacco crops gives good control of the black shank disease, provided various solanaceous plants are not used in the rotation (2) and recontamination of the soil is prevented. Dukes (3) reported that several nonhost crops, especially peanuts and rye-weeds, are much more effective than corn in reducing the incidence of black shank in Georgia. It is not known whether the crop or cultural practices employed for a specific crop are actually responsible for reducing population levels in the soil. Identifying the factors that influence the populations and activities of the fungus could lead to the development of improved methods of control. This investigation was initiated to study the effects of various hosts and nonhosts on population densities of the fungus in soils.

MATERIALS AND METHODS.—Artificially infested soil was prepared as follows: susceptible tobacco (cultivar Burley 21) was seeded in steam-pasteurized soil in plastic containers (27 × 32 × 12 cm deep with drainage holes) containing 9.1 kg of soil. Plants were inoculated at the 4- to 6-leaf stage with unstandardized zoospore suspensions of race 0 [Isolate 1156, ref. (7)] or race 1 [Isolate 1452, ref. (7)] of burley isolates of *Phytophthora parasitica* var. *nicotianae*. The plants were killed by the fungus within 4 wk. The dead stems and leaves were removed, and the soil in each container was mixed thoroughly and returned to its container before use in experiments. Seedlings were transplanted into the infested soil as described below.

Soil naturally infested with race 0 was collected from the rhizospheres of black shank-killed plants from a field in Scott County, Kentucky (6). This soil was mixed thoroughly in a concrete mixer, and 9.1-kg portions were placed in the plastic containers.

One or two containers for each plant species or cultivar were used in each experiment. Eight seedlings were transplanted into each container of naturally or artificially infested soil. At intervals, a composite soil sample of about 10 g from as close as possible to the bases of the eight plants of each container was collected. Plants were not uprooted. Quantitative determinations of propagule populations were made (5).

Plant species used were: tobacco (*Nicotiana tabacum* L. cultivars 'Burley 21', 'Burley 37', and 'Burley 21 × L8'); fescue (*Festuca arundinacea* Schreb. 'Kennell'); wheat (*Triticum aestivum* L. 'Arthur'); tomato (*Lycopersicon esculentum* Mill. 'Manapal'); cowpea (*Vigna unquiculata* L. 'California Blackeye'); and bean (*Phaseolus vulgaris* L. 'Pinto').

RESULTS.—Burley 21 plants transplanted into the artificially infested soils died within 2 wk. Burley 37 plants became stunted within 4 wk after transplanting, but aboveground symptoms of black shank were not observed for either race of the fungus. Burley 21 × L8 plants never developed black shank symptoms in soil infested with race 0 but all plants were killed within 3 wk after being transplanted into soil infested with race 1.

Both races increased rapidly in the rhizospheres of Burley 21 and, to a lesser extent, Burley 37 plants transplanted into the artificially infested soils (Table 1). Race 0 failed to increase appreciably around Burley 21 × L8 roots but neither did populations decrease. On the other hand, race 1 increased as well on Burley 21 × L8 as on Burley 21. None of the nonhost plants tested had any detectable effect on populations (Table 1). Populations decreased to some extent in fallow soils or soils planted to nonhosts.

Burley 21 plants transplanted into the soil naturally infested with race 0 died 5-6 wk after transplanting. Significant increases in populations of the black shank fungus occurred within 2 wk but reached maxima at 8 wk (Table 2). Black shank symptoms appeared on Burley 37 plants 4-8 wk after transplanting. Significant population increases occurred 4 wk after transplanting Burley 37 plants. Burley 21 × L8 plants never developed black shank symptoms, but populations of the black shank fungus increased, nevertheless. Tomato and wheat plants had no effect on populations of the black shank fungus.

While populations of total *Pythium* spp. increased significantly during the first 2 wk in each treatment except one, none of the treatments had a long-term influence on *Pythium* populations.

Populations of both the black shank fungus and *Pythium* spp. were unaffected by winter conditions (Table 2). This result is consistent with our earlier observation (6).

DISCUSSION.—These results reaffirm our earlier conclusion that population increases of *Phytophthora parasitica* var. *nicotianae* are related to pathogenesis (6). Populations of the *Pythium* spp. indigenous to the naturally infested soil were unaffected by any of the plant species evaluated, and populations of *Phytophthora parasitica* var. *nicotianae* increased in both artificially infested pasteurized soil or naturally infested soil only in the presence of a host. Transplanting a susceptible cultivar (Burley 21) into infested soil resulted in rapid disease development and rapid population increases. The subsequent apparent drop in populations may have been due to depletion of rhizosphere soil, which was limited by rapid killing of the entire root systems.

A moderately resistant cultivar (Burley 37) resulted in decreased disease development and a gradual increase in populations. Although these experiments were not designed to measure total population increases per plant, it is probable that Burley 37 plants produced higher populations than Burley 21, because more extensive root systems were produced before the plants were killed.

When transplanted into soil infested with race 1, Burley 21 × L8 rapidly produced population increases similar to those produced by Burley 21. Increases of race 0 would not be expected due to pathogenesis of Burley 21 × L8 roots (11), even though populations either failed to decline or increased to some extent. Stem tissues of L8, while highly resistant to race 0, are not immune (7). In the case where populations of race 0 increased with Burley 21

TABLE 1. Effect of hosts and nonhosts on soil populations (propagules/g dry soil) of the two races of *Phytophthora parasitica* var. *nicotianae* in artificially infested pasteurized soil[a]

Race	Plant	Relative resistance[b]	Time (wk) 0	2	4	6	8
Race 0	Tobacco						
	Burley 21	S	192	3803	2196	1210	1029
	Burley 37	M	316	783	346	517	787
	Burley 21 × L8	H	307	323	231	381	316
	Tomato	N	229	173	129	183	167
	Pinto bean	N	306	155	150	144	107
	Cowpea	N	209	144	117	126	126
	Wheat	N	259	149	138	153	199
	Fescue	N	255	342	170	219	141
	None		270	167	199	141	184
Race 1	Tobacco						
	Burley 21	S	349	1692	1837	1520	1223
	Burley 37	M	247	791	795	679	785
	Burley 21 × L8	S	304	1657	1770	1148	499
	Tomato	N	323	220	186	194	242
	Pinto bean	N	294	169	211	152	91
	Cowpea	N	318	203	259	258	188
	Wheat	N	286	193	259	256	161
	Fescue	N	339	276	167	197	185
	None		262	233	204	139	138

[a]Means of two experiments, one replication/experiment.
[b]Ratings: S = susceptible; M = moderately resistant ('Fla. 301' resistance); H = high resistance (*Nicotiana longiflora* resistance); N = nonhost and presumably immune.

TABLE 2. Effects of hosts and nonhosts on soil populations (propagules/g dry soil) of *Phytophthora parasitica* var. *nicotianae* (race 0) and *Pythium* spp. in naturally infested soil

	Time after transplanting (wk)					
	0	2	4	6	8	12
Phytophthora parasitica var. *nicotianae*[a]						
Tobacco						
Burley 21	34[b]	129	201	222	275	102
Burley 37	43	88	129	165	132	261
Burley 21 × L8	55	70	343	339	216	128
Tomato	61	33	37	59	34	36
Wheat	45	49	86	60	40	31
None	63	52	53	39	39	40
None (outside)[c]	45	69	39	47	48	51
Pythium spp.[d]						
Tobacco						
Burley 21	326[b]	502	486	523	488	517
Burley 37	430	569	492	655	517	516
Burley 21 × L8	301	614	516	509	439	534
Tomato	349	605	500	484	473	568
Wheat	291	654	492	501	510	489
None	430	516	506	483	410	501
None (outside)[c]	373	529	550	516	393	498

[a]LSD ($P = 0.05$) = 61; LSD ($P = 0.01$) = 82.
[b]Means of two replications.
[c]These soil samples were maintained outside the greenhouse. The experiment was started in October. The samples were subjected to freezing and thawing.
[d]LSD ($P = 0.05$) = 123; LSD ($P = 0.01$) = 164.

× L8 (Table 2), the increase occurred rapidly, as if a small amount of susceptible tissue were present.

In these experiments, soil populations were not affected by the presence of nonhosts. Clayton et al. (2) considered that tomatoes, peppers, Irish potatoes, and eggplants should not be used in rotations on black shank-infested soils but gave no rationale or evidence to support this conclusion. These crops are not known to be susceptible to the black shank fungus, and our data give no indication that tomato plants had any influence on populations of the fungus.

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