Reproduction, Penetration, and Pathogenicity of Pratylenchus penetrans on Tobacco, Vegetables, and Cover Crops

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ABSTRACT

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Thirteen cover or forage crops, 14 vegetable crops, eight tomato (*Lycopersicon esculentum*) cultivars, and four tobacco (*Nicotiana tabacum*) cultivars were examined in the greenhouse for susceptibility to root penetration by *Pratylenchus penetrans*. Of the cover and forage crops tested, Saranac alfalfa (*Medicago sativa*) and alsike clover (*Trifolium hybridum*) had the largest populations of *P. penetrans* per total root mass, while timothy (*Phleum pratense*) and reed canary grass (*Phalaris arundinacea*) had the smallest. Cucumber (*Cucumis sativus*), pea (*Pisum sativum*), and pumpkin (*Cucurbita pepo*) roots also contained large populations of *P. penetrans*, but none was found in asparagus (*Asparagus officinalis*) roots. Differences in root populations of *P. penetrans* occurred within cultivars of several crops. Neither root necrosis nor plant height, both indicators of damage by *P. penetrans*, were consistently correlated with *P. penetrans* populations within the roots. Knowledge of a plant's interaction with *P. penetrans* may enable the management of *P. penetrans* populations in the field by proper selection of crop plants.

Populations of *Pratylenchus penetrans* (Cobb 1917) Sher and Allen (1953) are influenced by the preceding crop (7, 10). It has been demonstrated that *Tagetes* spp. grown to maturity reduced root injury by *P. penetrans* to subsequent crops (7, 12). Brown root rot of tobacco (*Nicotiana tabacum* L.) caused by *P. minyus*, is more severe if tobacco succeeds corn (*Zea mays* L.) than if tobacco follows tobacco or fallowing. Root entry and browning following this entry by *P. penetrans* of roots of several grasses and legumes was studied because these crops often are used as cover or forage crops, and *P. penetrans* has been found around their roots (1, 2, 3, 4, 5, 11). Several vegetables and tomato and tobacco cultivars that may succeed the cover or forage crops were included.

MATERIALS AND METHODS

A fine sandy loam soil, naturally infested with approximately 330 *P. penetrans*/kg of soil was placed in 15-cm diameter plastic pots. Four pots each were seeded, depending upon the crop species, with 15 to 100 seeds of one of the grass or leguminous crops or other cover crops; these included alsike clover (*Trifolium hybridum* L.), red clover (*T. pratense* L. 'Penobscot'), alfalfa (*Medicago sativa* L. 'Narragansett' and 'Saranac'), corn (*Zea mays* L. 'Butter and Eggs'), oats (*Avena nuda* L.), rye (*Secale cereale* L.), orchard grass (*Dactylis glomerata* L.), reed canary grass (*Phleum arundinaceae* L.), timothy (*P. pratense* L.), Oregon rye grass (*Lolium multiflorum* Lam.), smooth Saratoga bromegrass (*Bromus inermis* Leyss.), and Sudan grass [*Sorghum vulgare* var. *sudanense* (Piper) Hitchc.]. The plants were maintained in the greenhouse at 25 ± 5 C. After 3 mo the roots were washed free of soil, rated for discoloration as an indicator of the amount of *P. penetrans* damage on a scale of 1 = no discoloration to 5 = severe damage or discoloration. Two 0.1-g samples of 1-cm sections of young roots were removed at random from the surface of the root ball of each plant to determine *P. penetrans* populations. Root samples were ground for 20 sec in a semi-micro Waring Blendor to release *P. penetrans* from the root tissues, and these were counted at ×50 magnification. All root populations of *P. penetrans* were counted this way in subsequent tests. Soil populations were not determined.

In another experiment, seedlings of several vegetables were grown in a sterilized peat moss-vermiculite-sand (1:1:1, v/v) planting mixture at 25 ± 5 C. Vegetables tested were asparagus (*Asparagus officinalis* L.), Brussels sprouts (*Brassica oleracea* var. *gemmifera* DC.), cabbage (*B. oleracea* var. *capitata* L.), cucumber (*Cucumis sativa* L.), dill (*Anethum graveolens* L.), eggplant (*Solanum melongena* L. 'Black Beauty'), lettuce (*Lactuca sativa* L.), okra (*Hibiscus esculentus* L.), parsnip (*Pastinaca sativa* L.), peas (*Pisum sativum* L.), pepper (*Capsicum annuum* L. 'All Big', 'California Wonder', 'Italian Sweet', and 'Sweet Banana'), pumpkin (*C. pepo* L.), and radish (*Raphanus sativus* L.). When the plants were about 5 cm tall, they were transplanted into soil containing 450 *P. penetrans*/kg of soil, or into the same soil previously frozen at −10 C for 72 hr to kill *P. penetrans* (6). Three wk later five seedlings of each vegetable cultivar were removed from infested and noninfested soils and individual root systems were assayed for *P. penetrans*. The heights of six plants was measured 4 wk after transplanting.

Susceptibility to *P. penetrans* of eight cultivars of tomato (*Lycopersion esculentum* Mill.) and four cultivars of tobacco (*Nicotiana tabacum* L.) was determined. Eight 3-wk-old tomato seedlings or 8-wk-old tobacco seedlings grown as before were transplanted to soil containing 450

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TABLE 1. Root populations of *Pratylenchus penetrans* and root necrosis caused by this nematode in cover and forage crop plants

Plant	P. penetrans[y] in: 0.1 g roots (no.)	Root system (no.)	Root necrosis rating[z]
Alsike clover	122 a	1,530 a	2.3 c
Saranac alfalfa	120 a	1,650 a	2.7 bc
Narragansett alfalfa	108 a	540 c	2.7 bc
Penobscot red clover	44 b	405 cd	3.0 b
Orchard grass	27 b	498 d	3.5 b
Rye	22 b	390 d	4.0 ab
Oats	15 bc	336 d	2.7 bc
Corn	7 c	824 b	2.8 bc
Timothy	5 c	64 ef	2.1 d
Oregon ryegrass	5 c	224 de	2.5 bc
Reed canary grass	5 c	163 e	1.8 d
Smooth Saratoga bromegrass	4 c	192 e	3.5 b
Sudan grass	4 c	240 de	5.0 a

[y]Values are an average of four replicate samples. Data were analyzed by Duncan's multiple range test and values in each column followed by same letter are not different, $P = 0.05$.

[z]Roots rated for necrosis (after washing) on a scale of 1 = no necrosis to 5 = severe necrosis.

TABLE 2. Population of *Pratylenchus penetrans* in roots of vegetables, and effect of the nematode on root necrosis and plant growth

Crop	*P. penetrans* per root system[w] (0.1 - 0.2 g)	Reduction in height (%)[x]	Root necrosis rating[y]
Asparagus	0 e[z]	0 f	2 d
Brussels sprouts	52 c	42 b	5 a
Cabbage	36 c	22 d	3 c
Cucumber	126 a	40 b	5 a
Dill	22 de	30 c	4 b
Lettuce	65 c	22 d	4 b
Eggplant			
Black Beauty	49 cd	15 de	5 a
Midway Hybrid	30 cd	18 de	5 a
Okra	35 cd	22 d	5 a
Peas	100 b	14 e	5 a
Parsnip	56 c	22 d	5 a
Pepper			
All Big	30 d	33 bc	4 b
California Wonder	8 e	8 e	4 b
Italian Sweet	8 e	8 e	4 b
Sweet Banana	36 cd	8 e	4 b
Pumpkin	88 b	17 de	4 b
Radish	60 c	57 a	5 a

[w]Seedlings infested with 45 *P. penetrans*/100 g of soil. Preliminary tests showed root population of *P. penetrans* did not increase much after 72 hr until egg hatch at 10 days (22 C).

[x]Percent reduction from noninfected controls.

[y]Roots were rated for necrosis on a scale of 1 = no necrosis to 5 = severe necrosis.

[z]The experiment was performed twice and values are averages for all observations. Data were analyzed by Duncan's new multiple range test and values in each column followed by the same letter are not significantly different, $P = 0.05$.

P. penetrans or to the same soil after it was frozen at −10 C for 72 hr. Plants were grown for 5 days at 22 ± 3 C. The entire root systems of four seedlings from each treatment were ground and the numbers of *P. penetrans* per root system were counted. The height of the remaining four tomato and tobacco plants in the infested and noninfested soils was measured after six wk of growth. After the roots were washed they were rated for discoloration as before. In all experiments, values are presented as averages for four replications and data were analyzed by Duncan's new multiple range test.

RESULTS

Alsike clover and alfalfa cultivars Narragansett and Saranac had the most *P. penetrans* per 0.1 g of roots (Table 1). Saranac alfalfa and alsike clover had the most *P. penetrans* per total root mass, but none of these had much root necrosis. Sudan grass, with a few *P. penetrans* per root system, had severe root discoloration, but reed canary grass had only slight root discoloration and only a few *P. penetrans* in the roots.

Roots of vegetables and tobacco from frozen soil had no *P. penetrans* and little discoloration. Cucumber, pea, and pumpkin root systems (approximately 0.1 to 0.2 g each) had the most *P. penetrans* (Table 2). No *P. penetrans* were in roots of asparagus and only a few were in roots of pepper cultivars California Wonder and Italian Sweet. Root browning was moderate to severe in roots of all except asparagus, which had no *P. penetrans*

TABLE 3. Population increase of *Pratylenchus penetrans* in roots of tomato and tobacco cultivars and the effects of the nematode on root necrosis and growth

Crop and cultivar	*P. penetrans* per root system[x] (0.1 - 0.2 g)	Reduction in height (%)[x]	Root necrosis rating[y]
Tomato:			
Beefeater	40 a[z]	54 a	4.1 ab
Bonny Best	21 bc	22 b	4.5 a
Fantastic	15 bc	32 b	4.7 a
Fireball	23 b	30 b	4.0 ab
Hybrid 980	13 c	21 b	3.7 b
Heinz 1350	21 bc	22 b	4.0 ab
Red Plum	41 a	30 b	3.7 b
Wonder Boy	15 bc	40 ab	4.5 a
Tobacco:			
Connecticut 49	19 ab	25 a	3.5 b
Consolidated L	2 b	8 b	2.8 b
Florida 301	28 a	32 a	5.0 a
Windsor Shade 117	11 b	13 b	3.3 b

[x]Five days after transplanting entire root systems of four seedlings grown in nematode-infested soil were ground and the released *P. penetrans* were counted. Six wk after transplanting the heights of four seedlings from each treatment were measured.

[y]Roots were rated on a scale of 1 = no necrosis to 5 = severe necrosis.

[z]The experiment was performed twice and values are averages for all observations. Data were analyzed by Duncan's new multiple range test and values in each column and crop followed by the same letter are not significantly different, $P = 0.05$.

in the roots but had some root discoloration, apparently due to other soil microorganisms.

Pratylenchus penetrans did not reduce growth of asparagus, and only slightly reduced the growth of peas and pepper cultivars California Wonder, Italian Sweet, and Sweet Banana. Radishes were stunted the most and Brussels sprouts and cucumbers were moderately stunted.

Cultivars of tomato differed in numbers of *P. penetrans* per root system (approximately 0.1 g) (Table 3). Red Plum and Beefeater roots had the most *P. penetrans*, with little difference in the number of *P. penetrans* per root system of other tomato cultivars. Cultivars Bonny Best, Fantastic, and Wonder Boy had more root discoloration and Wonder Boy and Beefeater were more stunted than the other cultivars.

Tobacco cultivars differed in susceptibility to *P. penetrans* (Table 3). Connecticut 49 and Florida 301 were the most stunted and susceptible to root invasion. Florida 301 had the most severe root discoloration.

DISCUSSION

The roots of all vegetables, cover and forage crops, and tobacco cultivars except asparagus, as previously reported (3) either supported populations of *P. penetrans* or were entered by *P. penetrans*. However, there were differences in root populations between varieties or cultivars. Since a preceding crop may influence nematode populations (9, 11), a cover or forage crop supporting large populations of *P. penetrans* would not be a good choice to precede another crop that is injured by this nematode, such as cucumbers or apples (8). However, vegetable crops which are poor hosts for *P. penetrans*, such as asparagus, may safely follow forage or cover crops that encourage a high population of *P. penetrans*.

Reductions in growth of some plants were not always correlated with the number of *P. penetrans* in the roots, eg growth of dill was reduced moderately even though there were few nematodes in the roots, whereas peas with a high number of nematodes in roots were only slightly stunted. Varieties and cultivars of the same crop differed in susceptibility. Over three times as many *P. penetrans* were in roots of Saranac alfalfa as in the roots of Narragansett alfalfa, and similar results were noted with the tomato and tobacco cultivars tested.

Root populations of *P. penetrans* were not always correlated with root discoloration or necrosis. Other soil factors and other micro-organisms may cause browning and these could change with the host. Roots also vary in phenolic content (6, 10). Roots of alsike clover contained many nematodes but had only moderate root necrosis. Sudan grass roots had few nematodes but severe root necrosis or discoloration. Sudan grass was previously reported to be a poor host for *P. penetrans* (1, 4). Once a root becomes discolored or necrotic, in some areas, it may repel *P. penetrans*, for phenolic compounds were shown to repel *P. penetrans* (4). *Pratylenchus penetrans* browned roots of rye grass but not bluegrass (4). Therefore, more discoloration of roots with high phenolic contents might follow only a few penetrations by *P. penetrans* than in roots with low phenolic contents and many *P. penetrans* in the roots.

Several factors must be considered when attempting to manage *P. penetrans* populations in the field by plant selection. These include the number of *P. penetrans* that will reside in the roots of the plant and the effect of this nematode on yield. Plants such as reed canary grass, bromegrass, timothy, asparagus, pepper cultivars California Wonder and Italian Sweet, and tobacco cultivars Consolidated L and Windsor Shade 117 may be useful, as well as *Tagetes* spp. (7, 11) in reducing *P. penetrans* populations in the field.

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