INFLUENCE OF FOUR SOIL TYPES ON POPULATION DEVELOPMENT OF *TYLENCHORHYNCHUS AGRI* ON *TRIFOLIUM PRATENSE*

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ABSTRACT

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Final populations of *Tylenchorhynchus agri* Ferris were larger in Cisne silt-loam than in Dana silt-loam, Onarga fine-sandy-loam, and Sparta loamy-fine-sand which were planted to 'Kenland' red clover (*Trifolium pratense* L.) or left fallow for seven months. Populations of *Helicotylenchus pseudorobustus* (Steiner) Golden and *Paratylenchus projectus* Jenkins were smaller in soil inoculated with *T. agri* than in uninoculated soil, for some soil types and treatments. There was no difference between the growth of plants in soil inoculated and not inoculated with *T. agri*.

Additional key words: ecology, nematode-nematode interactions, soil analysis, soil fumigation, soil texture.

RESUMEN

Coates-Beckford, Phyllis L. 1984. Infuencia de cuatro tipos de suelo en el desarrollo de las poblaciones de *Tylencohrhynchus agri* en *Trifolium pratense*. Nematropica 14:1-9.

Las poblaciones finales de *Tylenchorhychus agri* Ferris fueron mayores en el suelo Cisne franco-aluvión que en los suelos Dana franco-aluvión, Onarga franco-arenoso fino y Sparta francoso-arena fina, cuando fueron sembrados con trébol rojo 'Kenland' (*Trifolium pratense* L.) ó dejados en barbecho por siete meses. Las poblaciones de *Helicotylenchus pseudorobustus* (Steiner) Golden y *Paratylenchus projectus* Jenkins fueron más bajas en suelo inoculado con *T. agri* que en suelo no inoculado, para algunos tipos de suelo y tratamientos. No hubo diferencias en el crecimiento de las plantas en suelo inoculado y no inoculado con *T. agri*.

Palabras claves adicionales: ecologia, interacción nematodo-nematodo, análisis del suelo, fumigación del suelo, textura del suelo.

INTRODUCTION

Several plant species have been reported as hosts of *Tylenchorhynchus agri* Ferris (3) which occurs in the soils of Illinois. These hosts include many members of the Gramineae and Leguminosae, including both tropical and temperate species. Host range studies, conducted using Sparta loamy-fine-sand, showed that 'Kenland' red clover (*Trifolium pratense* L.) was one of many excellent hosts of the nematode because initial population densities of 100 *T. agri*/pot increased 140-fold on this host within 90 days (3). This study was carried out to investigate the effects of various soil types on the population development of *T. agri* on clover.

MATERIALS AND METHODS

The effects of four soil types on the reproduction of *T. agri* were studied under greenhouse conditions between August, 1975, and March, 1976. The soils tested were Sparta loamy-fine-sand (84.9% sand, 10.2% silt, 4.9% clay, 0.4% organic matter, pH 4.3), Onarga fine-sandy-loam (62.5% sand, 22.5% silt, 15.0% clay, 3.8% organic matter, pH 7.7), Dana silt-loam (7.7% sand, 66.5% silt, 25.8% clay, 3.0% organic matter, pH 5.7), and Cisne silt-loam (7.8% sand, 78.3% silt, 13.9% clay, 1.6% organic matter, pH 6.9). All essential elements were present in adequate amounts for plant growth but calcium was relatively high in Onarga fine-sandy-loam (10,024 kg/ha).

T. agri did not occur naturally in any of the four soils. Plant-parasitic nematodes present in Sparta loamy-fine-sand were *Xiphinema americanum* Cobb, *Heterodera weissi* Steiner, *T. capitatus* Allen, species of *Ditylenchus* Filipjev and *Tylenchus* Bastian, and members of the Dorylaimoidea. Those occurring in Cisne silt-loam were *Helicotylenchus pseudorobustus* (Steiner) Golden, *T. acutus* Allen, *T. martini* Fielding, *Hoplolaimus galeatus* (Cobb) Sher, and species of *Pratylenchus* Filipjev, *Aphelenchus* Bastian, and *Tylenchus* Bastian. Only *Paratylenchus projectus* Jenkins was present in Dana silt-loam. No plant parasites were detected in Onarga fine-sandy-loam.

A portion of each soil type was fumigated with 1,3-dichloropropene (0.06 ml ai/L soil) in closed plastic bags for 3 days in order to kill any phytoparasitic nematodes present. Subsequently, the bags were opened and the fumigant was allowed to dissipate for 3 days before potting the soil. No plant parasites were recovered from any of the soils when examined 3 days after fumigation.

For each soil type, groups of ten 12.5-cm diam clay pots were filled with 850 cm^3 of fumigated or unfumigated soil. The soil was watered periodically for 14 days before planting seeds of red clover cv. Kenland. After 7 days, the soil in each of 5 pots of each soil type and treatment, with 8 clover seedlings/pot, was inoculated with a suspension of 10,000 *T. agri*. The remaining 5 pots in each group were the uninoculated controls. A 10-ml suspension of nodulating bacteria, *Rhizobium trifolii*

Dangeard, was added to the soil surface of each pot. The pots were arranged on the greenhouse bench in a randomized complete block design. No fertilizer was applied to the soil during the trial. Powdery mildew was controlled by vaporizing elemental sulphur in the greenhouse, and damping-off by soil applications of suspensions of captan (500 ppm ai).

Shoots were clipped to 4 cm at monthly intervals and to soil level after growth for 7 mo. At the end of the experiment, the roots were washed free of soil. All plant parts were dried at 80C for 10 days and weighed. Nematodes were extracted from the soil using the method of Christie and Perry (2). Populations were estimated by determining the numbers in replicated 1-ml aliquots from 100-ml extract suspensions after a 48-hr extraction period. The data were analyzed by the analysis of variance and Duncan's multiple range test to detect significant differences between treatments.

A second trial was conducted simultaneously in order to determine the survival of *T. agri* in the absence of a host. Five pots of each unfumigated soil type were each inoculated with a suspension of 10,000 *T. agri* and left fallow for 7 mo. The pots were arranged in a randomized complete block design and watered as soon as the soil surface became dry. Five additional pots with soil of each type and treatment, but without *T. agri*, were maintained for determining the final concentrations of nutrients in the soil, after growth of red clover for 7 mo.

RESULTS

The final populations of *T. agri* were largest and increased only in pots with Cisne silt-loam planted to clover, and were larger in fumigated than in unfumigated soil (Table 1). However, populations of this species were similar in unfumigated and fumigated soil of the other three types. Populations in pots with Dana silt-loam and Onarga fine-sandy-loam changed little from the initial populations, whereas those in pots with Sparta loamy-fine-sand decreased significantly (Table 1). The populations of *T. agri* decreased significantly in pots of each soil except Cisne silt-loam when left fallow for 7 mo and were lowest in the loamy sand (Table 2). Population levels were similar in the sandy loam and Dana silt-loam. All developmental stages except the second stage juvenile were present.

Various plant-parasitic nematode species survived in both fumigated and fallow soil (Tables 1, 2). A comparison of fumigated and unfumigated soils which were or were not inoculated with *T. agri* frequently showed no differences in the numbers of phytoparasitic nematodes present (Table 1). However, where differences did occur, the unfumigated soil of each type usually had larger populations than the fumigated soil (Table 1). Populations of these nematodes were generally small, but those

Table 1. Numbers of plant parasitic nematodes recovered from 850 cm^3 of four soil types supporting growth of red clover, 7 months after inoculation of soil with 10,000 *Tylenchorhynchus agri*/12.5-cm diam pot.

Soil type	Treatment[y]	Nematode species[x] and final population							
		T.A.	P.P.	H.P.	C.	M.H.	T.	A.	D.
Sparta	UI	3200 b[z]	0 a	0 a	960 a	0 a	0 a	80 a	600 e
loamy-	UC	0 a	160 ab	200 a	628 a	0 a	200 abc	0 a	900 e
fine-	FI	2940 b	0 a	0 a	440 a	0 a	120 ab	80 a	0 a
sand	FC	0 a	0 a	240 a	300 a	0 a	160 ab	160 a	0 a
Onarga	UI	6720 cd	240 ab	160 a	0 b	0 a	240 abc	0 a	40 ab
fine-	UC	0 a	160 ab	720 b	80 b	0 a	280 bcd	0 a	80 abc
sandy-	FI	5620 c	80 a	80 a	0 b	0 a	200 abc	80 a	160 cd
loam	FC	0 a	200 ab	240 a	0 b	0 a	80 ab	240 a	120 abc
Dana	UI	8400 cd	960 abc	0 a	0 b	4680 b	80 ab	80 a	120 bcd
silt-	UC	0 a	12,600 de	280 a	0 b	6920 b	40 ab	360 a	280 d
loam	FI	15,700 d	6560 bc	0 a	0 b	0 a	0 a	160 a	0 a
	FC	0 a	39,760 de	0 a	0 b	0 a	0 a	200 a	40 ab
Cisne	UI	50,320 e	1520 abc	1200 b	0 b	0 a	480 cd	120 a	0 a
silt-	UC	0 a	61,040 cd	10,720 d	0 b	0 a	720 d	0 a	0 a
loam	FI	88,240 f	12,040 cd	320 a	0 b	0 a	0 a	40 a	40 ab
	FC	0 a	82,000 e	4200 c	0 b	0 a	0 a	80 a	0 a

[x]T.A. = *Tylenchorhynchus agri*, P.P. = *Paratylenchus projectus*, H.P. = *Helicotylenchus pseudorobustus*, C. = *Criconemella* sp., M.H. = *Meloidogyne hapla*, T. = *Tylenchus* sp., A. = *Aphelenchus* sp., D. = Dorylaimoidea.

[y]U = unfumigated, F = fumigated, I = inoculated, C = uninoculated.ed.

[z]Each value is the mean of 5 observations; column means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

Table 2. Mean numbers of plant-parasitic nematodes recovered from 850 cm^3 of unfumigated, fallow soil of four types, 7 months after inoculation of soil with 10,000 *Tylenchorhynchus agri*/12.5-cm diam pot.

Soil type	Nematode species and final population			
	Tylenchorhynchus agri	*Tylenchus* sp.	*Aphelenchus* sp.	Dorylaimoidea
Sparta loamy-fine-sand	2140 a[a]	281 a	0 a	743 a
Onarga fine-sandy-loam	5160 b	1 b	0 a	173 b
Dana silt-loam	5367 b	81 b	80 a	53 c
Cisne silt-loam	9050 c	2364 c	0 a	83 c

[a]Each value is the mean of five replicates; column means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

of *P. projectus* and *H. pseudorobustus* reached high levels in both silt-loams and in Cisne silt-loam, respectively, when planted to clover. Populations of *P. projectus* were smaller in each silt-loam when inoculated with *T. agri* than in the uninoculated control for both fumigated and unfumigated soil (Table 1). Populations of *H. pseudorobustus* were smaller in unfumigated Onarga fine-sandy-loam and both unfumigated and fumigated Cisne silt-loam which were inoculated with *T. agri,* than in the uninoculated controls (Table 1). There were no differences in population levels of the remaining species in *T. agri*-inoculated and uninoculated soil, whether fumigated or unfumigated. Populations of *Tylenchus* sp. in fallow soil were largest in Cisne silt-loam, smaller in the loamy sand, and reached the lowest levels in the sandy-loam and Dana silt-loam (Table 2). Those of the Dorylaimoidea were largest in the loamy-sand and smallest in the silt loams whereas there were no differences among population levels of *Aphelenchus* sp. in each soil (Table 2).

Shoot growth of clover was best in Cisne silt-loam and poorest in Onarga fine-sandy-loam (Table 3). There were no differences in the dry weights of cumulative clippings of plants grown in Sparta loamy-fine-sand and Dana silt-loam. Shoot growth was better in fumigated than in unfumigated soil for all soil types except Onarga fine-sandy-loam. There were no differences between the dry weights of cumulative clippings of plants grown in soil inoculated and not inoculated with *T. agri*. Root growth was poorer in the sandy-loam than in the other soil textures (Table 3). Fumigated Sparta loamy-fine-sand and Cisne silt-loam supported better growth of roots than unfumigated soil. There were no differences between the dry weights of roots grown in unfumigated and fumigated Onarga fine-sandy-loam or Dana silt-loam. Neither were there differences between the root weights of plants grown in soil inoculated

Table 3. Dry weights of cumulative clippings and roots of red clover, 7 months after inoculation of unfumigated and fumigated soil with 10,000 *Tylenchorhynchus agri*/12.5-cm diam pot.

	Weight (g)		
Soil type	All treatments[w]	Unfumigated and fumigated soil[x]	Uninoculated and inoculated soil[x]
Cumulative clippings			
Sparta loamy-fine-sand	2.71 a[y]	2.40 U[z]	2.45 C[z]
		3.03 F*	2.98 I
Onarga fine-sandy-loam	0.63 b	0.62 U	0.70 C
		0.64 F	0.56 I
Dana silt-loam	2.71 a	2.22 U	2.90 C
		3.19 F*	2.51 I
Cisne silt-loam	3.13 c	2.73 U	3.32 C
		3.52 F*	2.93 I
Roots			
Sparta loamy-fine-sand	0.31 a	0.26 U	0.25 C
		0.36 F*	0.37 I
Onarga fine-sandy-loam	0.06 b	0.06 U	0.06 C
		0.06 F	0.06 I
Dana silt-loam	0.41 a	0.41 U	0.31 C
		0.41 F	0.50 I
Cisne silt-loam	0.30 a	0.23 U	0.29 C
		0.36 F*	0.31 I

[w,x]Each value is the mean of 20 and 5 observations, respectively.
[y]Column means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.
[z]U = unfumigated, F = fumigated, C = uninoculated, I = inoculated; asterisk (*) indicates significant difference from the respective control ($P \leq 0.05$).

and not inoculated with *T. agri* (Table 3). There were no correlations between shoot or root weights and numbers of nematodes.

Chemical analyses of the soils at the end of the trial showed similar values for macronutrients and pH in fumigated and unfumigated soil planted to clover for 7 mo. The only nutrients showing increased concentrations were magnesium and calcium in the loamy-sand (from 48 to 200 kg/ha and 120 to 600 kg/ha, respectively) and potassium and magnesium in Cisne silt-loam (from 300 to 800 kg/ha and 150 to 350 kg/ha, respectively). Initial and final levels of the remaining elements were similar in all soils. The pH increased to values of 6.3 in the loamy sand, 8.0 in the sandy-loam, 6.9 in Dana silt-loam, and 7.9 in Cisne silt-loam.

DISCUSSION

During the trial, the daily mean soil temperatures, which ranged from 22.0C in January to 28.0C in August, were below the optimum temperature of 30C for the reproduction of *T. agri* (4,5,8). Therefore, the low levels of the final populations of *T. agri* noted in March in the loamy-sand, sandy-loam, and Dana silt-loam planted to clover may have been due to the low temperatures prevailing during the preceding winter months. However, the characteristics of Cisne silt-loam appeared to be favourable for the reproduction of *T. agri*, despite the suboptimal temperatures prevailing during the trial. *T. agri* was able to survive for a long period in the absence of a host in all the soils tested, a characteristic shown by other species of *Tylenchorhynchus* Cobb (7,10). The characteristics of Cisne silt-loam seemed to be most favourable for the survival of *T. agri*.

Despite the fumigation of soil, plant-parasitic nematode species survived in each soil type, probably because some eggs which were initially present escaped the action of the fumigant. All the species identified, except *Tylenchus* sp. and *Aphelenchus* sp., are known parasites of red clover (6) but their populations were small. The various species of phytoparasitic nematodes present in the soil may have modified the population growth of each other through competition for feeding sites. Populations of *T. agri* inhibited the population increase of *Meloidogyne naasi* Franklin (11), but *T. agri* was inhibited by *M. hapla* Chitwood and *Pratylenchus penetrans* (Cobb) Filipjev and Schuurmans Stekhoven (1). The initially large numbers of *T. agri* present in the soil probably resulted in smaller phytoparasitic nematode populations occurring in some *T. agri*-inoculated soils than in the uninoculated controls (Table 1).

The best growth of clover occurred in Cisne silt-loam and probably resulted in a greater number of feeding sites being available for supporting reproduction of *T. agri* before the advent of low winter temperatures.

In addition, this silt-loam had less organic matter than Dana silt-loam, which may have favoured nematode population growth (9). The early growth of clover in Onarga fine-sandy-loam was poor because of damping-off of seedlings. The relatively high levels of calcium in the sandy-loam and high soil pH may also have reduced the availability of essential nutrients to plants, contributing to poor plant growth which would adversely affect reproduction of *T. agri*.

Therefore, of the four soil types tested, the characteristics of Cisne silt-loam appeared to be the most favourable for the growth of red clover and for the reproduction and survival of *T. agri*.

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