Full Length Research Paper

Diversity and distribution of soil nematodes in Ngere tea catchment area of Murang'a county, Kenya

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A survey was conducted to determine the diversity and distribution of soil nematodes associated with tea in Ngere tea catchment area in Kenya. Soil samples were collected from six electoral zones of Ngere factory in Gatanga division Thika district, Murang'a County, Kenya. Nematodes were extracted and recovered from soil samples using a modified Baermann funnel method and identified under a light microscope based on their morphological characters. They were also classified according to their feeding habits. Ten genera belonging to, bacteriovores, fungivores, and omnivores were identified. Fungal feeding and parasitic nematodes were the most widely distributed trophic groups across the tea catchment area. Plant-parasitic nematodes recovered included *Pratylenchus* spp., *Helicotylenchus* spp.*, Rotylenchus* spp., *Aphelenchus* spp.*, Rotylenchulus* spp., and *Xiphinema* spp*. Tylenchus* spp was the most frequently occurring species in the soil (60.47%) where the population was 429 followed by *Pratylenchus* spp with 55.81% frequency rating and a population of 404 while *Aphelenchus* spp had frequency rating of 48.84% and a population of 530. *Ditylenchus* and *Rotylenchus* spp had the lowest frequency rating of 6.98 and 4.65%, respectively, while *Rotylenchus* spp had the lowest population of 33. Six genera of plant parasitic nematodes were encountered in the collected soil samples. These plant parasitic nematodes were identified as *Pratylenchus* spp., *Aphelenchus* spp., *Helicotylenchus* spp., *Tylenchus* spp., *Xiphinema* spp and *Duotylenchus* spp. *Pratylenchus* spp. and *Tylenchus* spp. were the most frequently occurring species in the soil (50%) with a population of 25 and 21, respectively, which was followed by *Helicotylenchus* spp., *Aphelenchus* spp., *Xiphinema* spp., and *Duotylenchus* spp. with 16.67% frequency rating and a population of 10, 10, 3 and 20, respectively. *Pratylenchus* spp had the highest nematode population of 28.09% and the lowest nematode population was *Xiphinema* spp., having a population of 3.37%. The correlation between nematode population counts and total organic carbon content was not significant at P≥0.05.

Key words: Tea, frequency, nematode population, carbon content, *Pratylenchus* spp., *Helicotylenchus* spp., *Rotylenchus* spp., *Aphelenchus* spp., *Rotylenchulus* spp., and *Xiphinema* spp.

INTRODUCTION

Tea (*Camellia sinensis* (L.) O. Kuntze) plant is an important source of different beverages which are claimed to be the most widely consumed fluids after water. It is grown in many countries ranging from as far

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north as 49° N, outer

Carpathians to as far as 30° S; Natal, South Africa and from altitudes varying from sea level in Japan to 2700 m above mean sea level (amsl) in Olenguruone, Kenya and Gisovu, Rwanda. The plant is widely adaptable to geographical areas with large variations in climate and physical features which affect rates of growth, yields and quality (Owuor et al., 2010; Sarkar et al., 2010).

Nematodes are small worm-like organisms which are present in almost all agroecosystems where they interact directly and indirectly with plants and other microfauna, regulating decomposition and release of nutrients to the plants (Colman et al., 1984). Nematodes are ubiquitous and have diverse feeding habits and life strategies ranging from colonizers to persistors (Bongers, 1990; Yeates and Bongers, 1999). Due to their diversity in biological and particularly feeding habits, nematodes are an integral part of the food webs in soil ecosystems (Yeates et al., 1993). In almost every soil sample, nematodes from five trophic levels namely bacteriovores, fungivores, herbivores, predators and omnivores are usually represented (Freckman and Baldwin, 1990). Plant parasitic nematodes are the most intensively studied group because of their economic importance as biotic constraints to crop production. However, as the role of soil nematodes in regulating soil bacterial and fungal populations and thus cycling of major soil nutrients becomes clear (Yeates and Bongers, 1999). Consequently, overall focus is shifting from plant parasitic nematodes to the entire nematode community in the soil. The diversity of nematodes in agro-ecosystems and the total abundance of members of different trophic levels are largely controlled by the biophysical, chemical and hydrological conditions of the soil (Yeates and Bongers, 1999). This study focused on the identification of soil nematodes as well as their diversity in small holder tea growing farms in Ngere tea catchment area, Murang'a County, Kenya.

MATERIALS AND METHODS

Rhizosphere soils were sampled from Ngere tea catchment area where thirty seven farms, each selected in thirty seven tea buying centers, were considered in Ngere factory in Gatanga division Thika district, Murang'a county, Kenya. Soil sample (ca. 400 g) was a composite of 3 to 10 random sub-samples, taken at least 8 to 10 m apart, from the surface to a depth of 45 cm of the four cardinal points of the rhizosphere of the tea bush. All sub-samples were mixed together and placed in a paper bag and then a polythene bag to prevent water loss and kept in a cooler (ca. 15°C) during transit to the laboratory as suggested by Kaya and Stock (1997). The samples were thoroughly mixed and 20 cm^3 of each soil samples was used for nematode extraction using modified Baermann funnel technique. Nematode numbers were counted, population of each genera was determined and identification to genus level was done under a compound microscope at a magnification of ×400 to ×1000 (Karuri et al., 2010).

Nematode genera were assigned to trophic groups (bacterial and fungal feeders, plant parasites, omnivores and predators) as described by Yeates et al. (1993). Taxonomic groups were also

assigned to colonizer-persistor (cp) values according to Bongers (1990). Physical and chemical properties of soil were measured. Total organic carbon (C) was estimated through Walkley and Black method. Relationships between soil organic carbon content and nematode population were derived using correlation analysis. All statistical computations were performed using XLSTAT version 7.5 (Addin software, New York). The population densities of different nematode species in the samples were calculated using the formulae:

$$*\text{Frequency rating} = \frac{\text{Number of times individual nematodes occurred}}{\text{Sample size}} \times 100$$

$$**\text{Nematode population} = \frac{\text{Number of individuals of a species in a sample}}{\text{Total of all individuals in a sample}} \times 100$$

(Norton, 1978).

RESULTS

Ten genera of plant parasitic nematodes were encountered in rhizosphere soil samples collected from Ngere tea catchment area. In the soil, plant parasitic nematodes identified were *Pratylenchus* spp., *Helicotylenchus* spp., *Rotylenchus* spp., *Aphelenchus* spp., *Rotylenchulus* spp. and *Xiphinema* spp. *Tylenchus* spp. was the most frequently occurring species in the soil (60.47%) where the population was 429/20 cm^3 of soil which was followed by *Pratylenchus spp* with 55.81% frequency rating and a population of 404/20 cm^3 of soil while *Aphelenchus* spp had frequency rating of 48.84% and a population of 530/20 cm^3 of soil (Table 1). *Ditylenchus* and *Rotylenchus* spp had the lowest frequency rating of 6.98 and 4.65%, respectively while *Rotylenchus* spp had the lowest population of 33/20 cm^3 of soil (Table 1).

Six genera of plant parasitic nematodes were encountered in infected soil samples collected. In the soils with infected plants, plant parasitic nematodes identified were *Pratylenchus* spp., *Aphelenchus* spp., *Helicotylenchus* spp., *Tylenchus* spp., *Xiphinema* spp and *Duotylenchus* spp. *Pratylenchus* spp. and *Tylenchus* spp. were the most frequently occurring species in the soil (50%) with a population of 25/20 and 21/20 cm^3 soil, respectively, which was followed by *Helicotylenchus* spp., *Aphelenchus* spp., *Xiphinema* spp., and *Duotylenchus* spp. with 16.67% frequency rating and a population of 10/20, 10/20, 3/20 and 20/20 cm^3 of soil, respectively. *Pratylenchus* spp had the highest nematode population of 28.09% and the lowest nematode population was *Xiphinema* spp., having a population of 3.37% (Table 2).

Two fungal genera (*Aphelenchus* and *Cervidellus*) were recorded. Only one genus (*Dorylaimus*) of omnivore nematodes and (*Cervidillus*) of bacteriovores were observed. Fungal feeding and parasitic nematodes were the most abundant trophic groups (Table 3). The correlation between nematode population and organic carbon content was not significant at P ≥ 0.05.

Table 1. Nematodes extracted from soils around the roots of Tea bushes in Ngere.

Nematode genera	C-P values	Population/20 cm³ of soil	Frequency of occurrence	Frequency rating* (%)	Nematode population** (%)
Aphelenchus	2	530	21	48.8	25.9
Cervidellus	2	140	12	27.9	6.8
Ditylenchus	2	39	3	7.0	1.9
Dorylaimus	4	126	5	11.6	6.2
Doutylenchus	2	77	6	14.0	3.8
Helicotylenchus	3	127	6	14.0	6.2
Pratylenchus	3	404	24	55.8	19.8
Rotylenchus	3	33	2	4.7	1.6
Tylenchus	2	429	26	60.5	21.1
Xiphinema	5	139	10	23.3	6.8

* n/N × 100 (n = number of times individual nematodes occurred and N = Sample size (43). ** In/TN × 100 (In = Individual nematode in all the samples and TN = Total Population of all the nematodes extracted in all the samples).

Table 2. Nematodes extracted from infected soils around the roots of tea bushes.

Nematode genera	Population/20 cm³ of soil	Frequency of occurrence	Frequency rating* (%)	Nematode population** (%)
Pratylenchus	25	3	50	28.1
Tylenchus	21	3	50	23.6
Helicotylenchus	10	1	16.7	11.2
Aphelenchus	10	1	16.7	11.2
Xiphinema	3	1	16.7	3.4
Duotylenchus	20	1	16.7	22.5

* n/N × 100 (n = number of times individual nematodes occurred and N = Sample size (6). ** In/TN × 100 (In = Individual nematode in all the samples and TN = Total Population of all the nematodes extracted in all the samples).

Table 3. Extracted nematodes according to their trophic group.

Family	Genera	C-P Values	Trophic group
Anguinidae	*Ditylenchus*	2	[d]FF
Pratylenchidae	*Pratylenchus*	3	[a]PF
Tylenchidae	*Tylenchus*	2	[a]PF
Longidoridae	*Xiphinema*	5	[a]PF
Aphelenchidae	*Aphelenchus*	2	[d]FF
Cephalobidae	*Cervidellus*	2	[b]BF
Tylenchidae	*Doutylenchus*	2	[a]PF
Dorylaimidae	*Dorylaimus*	4	[c]OM
Hoplolaimidae	*Rotylenchus*	3	[a]PF
Hoplolaimidae	*Helicotylenchus*	3	[a]PF

C-P: Colonizer-persister scale 1-5 where cp 1 are colonizers characterized by short generation time and cp 5 are persisters characterized by long generation time (Bongers, 1990). [a]Plant feeders [b]Bacteriovores [c]Omnivores.

DISCUSSION

Nematodes in an agro-ecosystem are potential bio-indicators due to their diversity and their relationships to soil processes (Yeates and Bongers, 1999). The nematode community structure can be used to assess changes in soil since these organisms respond rapidly to new resources (Bongers and Bongers, 1998). This study has demonstrated nematodes of the genera *Aphelenchus* spp., and *Pratylenchus* spp., are wide spread in the tea fields of Ngere catchment area. These findings are in agreement with the previous studies elsewhere (Kimenju

Table 4. Correlation between nematode population and organic carbon content.

Variable	p-values	
	Nematode population	Organic carbon content
Nematode population	0	0.173
Organic carbon content	0.173	0

Values in bold are different from 0 with a significance level alpha = 0.05.

et al., 2009). Large numbers of fungal feeders were identified (Tables 1 and 3) and this could be an indication of decomposition of substrates with high C:N ratios by fungi. The high abundance of fungal feeding nematodes could also be attributed to colonization of tea roots by large numbers of fungi. Similar findings have been observed by Feng et al. (2003) and Koenning and Barker (2004).

The condition of soils in Ngere tea catchment area can be improved by enhancing nutrient availability and providing habitat for beneficial soil organisms. Maintenance of large populations of bacterial-feeding and fungal feeding nematodes with practices that promote N mineralization may enhance crop productivity, but a surplus of mineral N is not desirable from the environmental point of view because of an increased risk of nitrate leaching (Neher, 1999). Cultural practices like tillage or cultivation may reduce the complexity of the soil food web. Thus, a decrease in the frequency and intensity of tillage may promote the conservation of predatory nematodes and contribute to improved farming system performance.

Conclusion

The study has demonstrated that Ngere tea catchment area harbours soil nematode species, 10 genera were isolated, characterized and identified. The findings also showed that the tea soils in Ngere tea catchment area had a high occurrence of fungal feeding nematodes.

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