PLANT-PARASITIC NEMATODES ASSOCIATED WITH COFFEE (*COFFEA ARABICA* L., RUBIACEAE) IN ETHIOPIA

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ABSTRACT

Mekete, T., R. A. Sikora, S. Kiewnick, and J. Hallmann. 2008. Plant-parasitic nematodes associated with coffee (*Coffee arabica* L., Rubiaceae) in Ethiopia. Nematropica 38:177-186

A survey of plant-parasitic nematodes in coffee was conducted on 132 sites of different agroecologies in Ethiopia. Samples from each site were collected during the wet season of 2004 and the dry season of 2006. Plant-parasitic nematode genera recovered were: *Helicotylenchus, Scutellonema, Rotylenchus, Xiphinema, Heterodera* and *Tylenchorhynchus. Helicotylenchus* predominated throughout the area (65-74%), followed by *Xiphinema* (29-40%). *Heterodera* occurred at a frequency of 8-10% and reached the highest population density of any nematode taxa with 3310 juveniles per 100 g soil. Nematode densities were generally lower in the dry season than in the wet season, however, relative abundance of nematode taxa was in the same order. A wide spectrum of free living nematodes belonging to 8 different families were also observed, of which *Dorylaimidae, Cephalobidae* and *Rhabditidae* were the most common. Nematodes considered to be of economic importance in coffee decline were not detected in this survey.

Key words: Agroecologies, biodiversity, coffee, Ethiopia.

RESUMEN

Mekete, T., R. A. Sikora, S. Kiewnick and J. Hallmann. 2008. Nematodos fitoparásitos asociados al cultivo del café (*Coffee arabica* L., *rubiaceae*) en Etiopía. Nematropica 38:177-186.

Se condujo un censo de nematodos fitoparásitos asociados al cultivo del café en 132 sitios en Etiopía. Se colectaron muestras de cada sitio durante la temporada húmeda de 2004 y la temporada seca de 2006. Se encontraron los siguientes géneros de nematodos fitoparásitos: *Helicotylenchus, Scutellonema, Rotylenchus, Xiphinema, Heterodera* and *Tylenchorhynchus.* El género más predominante en toda la extensión muestreada fue *Helicotylenchus* (65-74%), seguido de *Xiphinema* (29-40%). Se encontró *Heterodera* con una frecuencia del 8-10% y en la densidad de población más alta de todos los nematodos, con 3310 juveniles por 100 g de suelo. Las densidades de población fueron generalmente menores durante la temporada seca, pero la abundancia relativa de los diferentes géneros se mantuvo. También se observó una amplia gama de nematodos de vida libre pertenecientes a 8 familias, de las cuales *Dorylaimidae, Cephalobidae* y *Rhabditidae* fueron las más comunes. En este censo no se hallaron nematodos considerados de importancia económica en la producción de café.

Palabras clave: Agroecología, biodiversidad, café, Etiopía.

Arabica coffee (*Coffea arabica* L, Rubiaceae) is parasitized by several species of nematodes. Since this species of coffee probably evolved in the highlands of Southwest and Southeast Ethiopia, where wild coffee plants still grows naturally in the undergrowth of the Afromontane rainforests at altitudes between 1000 and 2000 m. (Denich and Gatzweiler, 2006), it would be logical to argue that considerable scientific information could be obtained from learning about the nematodes feeding on the coffee be grown in the region. Several plant-parasitic nematodes are currently recorded from Ethiopia (Abebe and Geraert, 1995; Bogale *et al.*, 2004; Godfrey *et al.*, 1988; O'Bannon, 1975; Marais *et al.*, 2005; Wondirad and Mekete, 2002; Van Den Berg *et al.*, 2004). For coffee, the nematode situation in Ethiopia still needs further exploitation.

Plant-parasitic nematodes on coffee have been reported from many countries worldwide, including very damaging species such as *Meloidogyne exigua, M. incognita, M. coffeicola* and *Pratylenchus coffeae* (Campos and Villain, 2005). In many African countries, plant-parasitic nematodes are major pests of coffee. For example, a unique group of root-knot nematode species, known as the African coffee root-knot nematodes, cause severe root damage to coffee in Tanzania and Kenya (Bridge, 1984; Campos and Villain, 2005). Species of this group include *M. africana, M. decalineata, M. kikuyensis* and *M. megadora.* In Tanzania, 16 genera of plant-parasitic nematodes were recorded in coffee, but only three species of *Meloidogyne* were considered important: *M. decalineata, M. africana* and another unidentified species. For the northern coffee districts of Tanzania, yield losses attributed to those nematodes are at least 20% (Bridge, 1984).

The objectives of this study were to determine the distribution and occurrence of plant-parasitic nematodes at one point in time in coffee growing agroecologies of Ethiopia comparing one wet growing season with one dry growing season.

A survey was conducted to determine the species composition of plant-parasitic nematodes present from different coffee growing agro-ecologies of Ethiopia during the wet season in August, 2004 and dry season in April, 2006. Each production region was divided into 15 20 km^2 grids, each representing a combination of agroecologies and plantation types (forest, semi-forest, garden and plantation) were studied.

Soil samples were taken from 132 sites. Each sample consisted of four to ten spades taken from the top 25-30 cm of soil and composited yielding from 1.0 to 1.5 kg soil/sample. Samples were taken predominantly from coffee trees with no or little ground cover vegetation. However, at sites with weeds and intercrops in close proximity to the coffee trees, the additional vegetation was recorded to later allow cross references of nematode data with non-target host plants. The elevation, latitude and longitude for each sampling site were recorded using a Global Positioning System (GPS) (Garmin etrex C, Garmin International Inc., KS, USA). Geographical coordinates recorded during for each farm were mapped with ArcView 3.2 (Fig. 1).

Two hundred gram soil samples were immersed in a bucket containing 2 liters of water and hand-stirred gently until all soil aggregates were dispersed. The soil suspension was then poured through a sieve with 250 mm openings and collected in a bucket. This step was repeated three times. Then the soil suspension collected in the bucket was poured through a sieve with 100 µm openings. Again this step was repeated three times and followed by further sieving steps with descending aperture sizes of 50 µm, 38 µm, and 25 µm. Material retained on each of the sieves was backwashed with

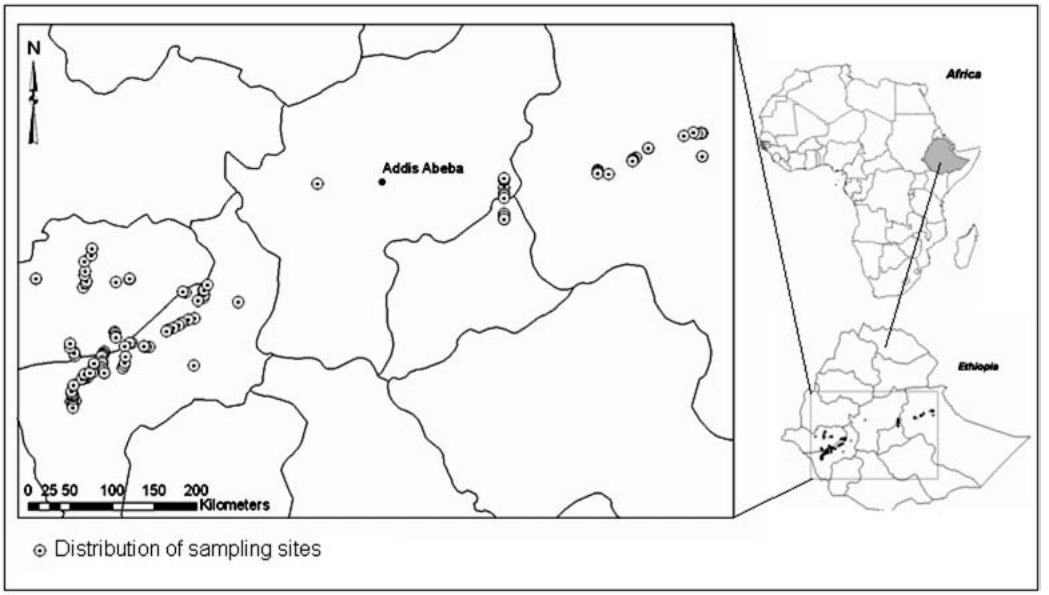

Fig. 1. Distribution of coffee sampling sites in Ethiopia. ○ Sampling sites

100 ml of water delivered as a fine stream. The final 400-600 ml sample was collected in beakers and the particulate contents were allowed to settle for 24 hours. The supernatant fluid was then siphoned from the beaker and the sediment containing the nematodes was placed on Baermann funnels for 24 hours (Hopper, 1985). The extracted nematodes were assessed microscopically in a round counting dish at 40X. All plant-parasitic nematodes were identified to the genera level and counted (Loof and Luc, 1990; Lamberti *et al.*, 2004; Mai and Mullin, 1996). Nematode population levels were expressed as number of specimen per 100 g soil. Frequency of occurrence, population density and prominence value (Prominence value (PV) = Population density X √frequency of occurrence / 10) were calculated (De Waele *et al.*, 1998).

The most abundant plant-parasitic nematode genera found were *Helicotylenchus, Scutellonema, Rotylenchus, Xiphinema, Heterodera* and *Tylenchorhynchus*. Genera observed with less frequency included *Ditylenchus, Trophurus, Criconemella, Hoplolaimus, Pratylenchus* and *Meloidogyne*. Selected species identified were *Helicotylenchus dihystera, H. multicinctus, H. californicus, H. gerti, Xiphinema insigne, X. basilgoodeyi, Scutellonema paralabiatum, Rotylenchus unisexus, Tylenchorhynchus agri* and *T. acti*.

Eighty percent of the soil samples contained two or more genera of plant-parasitic nematodes and 6.3% of the soil samples contained only a single genus. Of the samples containing two or more genera of plant-parasitic nematodes, 26.7% of the samples contained two genera, 20% contained three genera, and 33.3% contained four and more genera. Plant-parasitic nematodes were not detected in 13.7% of the total samples. *Helicotylenchus* species was found in 73.3% and 55% of the wet and dry season samples with maximum population densities of 1480 and 640 nematodes/100 g soil, respectively (Fig. 2). Prominence values were 639 for the wet season and 282 for the dry season. *Xiphinema* was

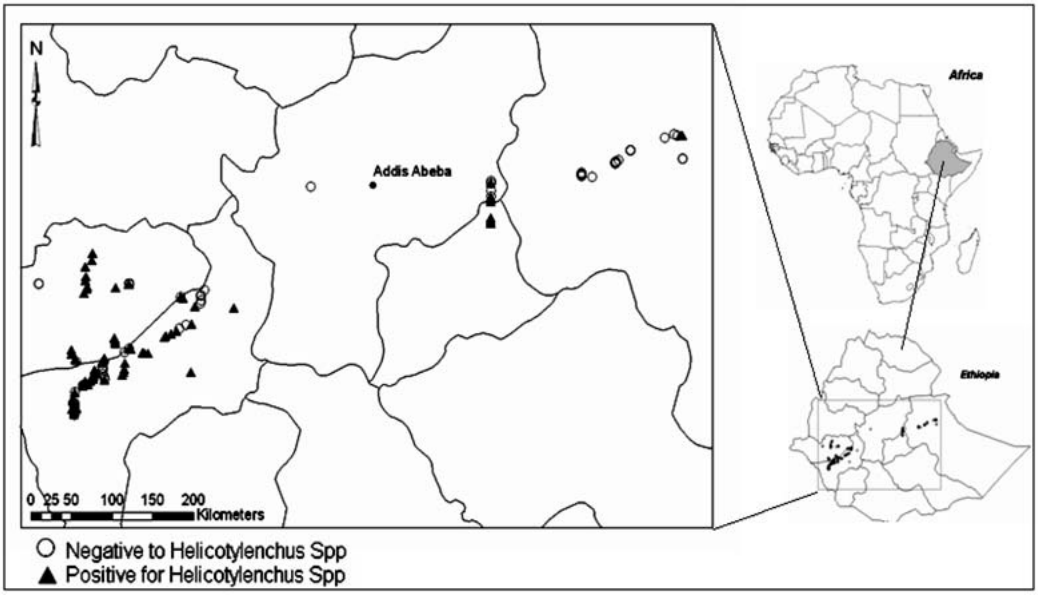

Fig. 2. Distribution of Helicotylenchus sp in different coffee agroecologies. ○ = negative sampling sites ▲ positive sampling sites

recovered from the soil in 40% and 22% of the sampling times with maximum population density of 870 and 155 nematodes/100 g of soil and prominence values of 221 and 73 in wet and dry seasons, respectively (Table 1; Fig. 3; Fig. 4). Both genera were detected in most sampling sites irrespective of coffee growing regions and plantation types.

Table 1. Frequency of occurrence, population density and prominence value of major plant-parasitic nematodes recorded from different plantation types of coffee growing agroecologies from Ethiopia.

Genera ID	Frequency of occurrence (%)		Population density/100 g soil				Prominence value	
			Mean		Maximum			
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Helicotylenchus	73	55	373	190	1480	620	639	282
Xiphinema	40	22	174	78	870	155	221	73
Tylenchorhynchus	36	38	85.5	42	400	260	103	52
Rotylenchus	34	32	229	105	2175	670	268	119
Scutellonema	27	25	95	58	750	130	97	58
Criconemella	20	20	147	74	1410	160	132	15
Trophurus	10	10	66	44	250	70	43	28
Heterodera	10	8	369	119	3310	1195	233	67

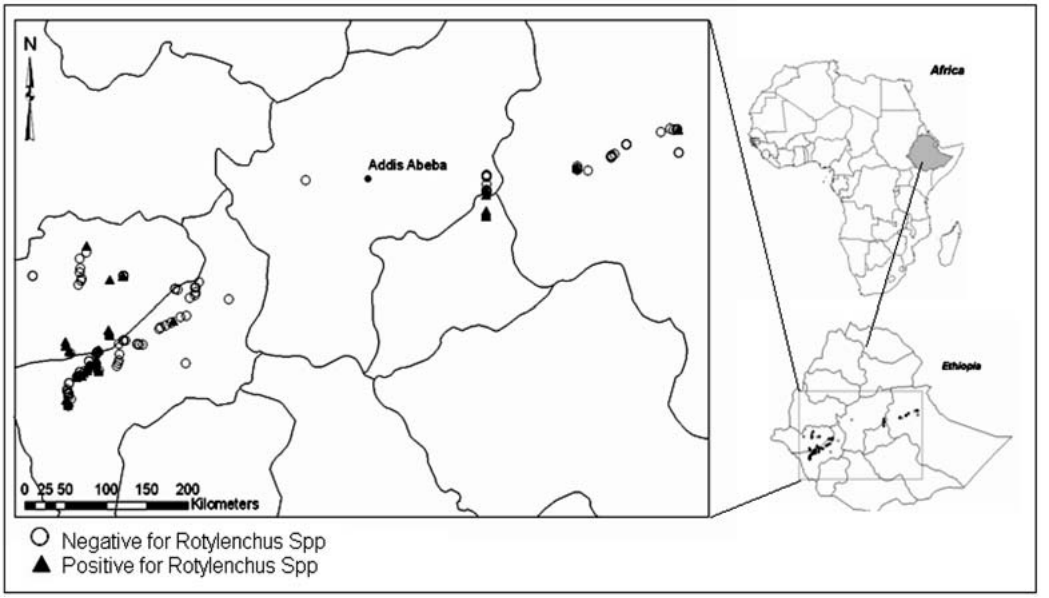

Fig. 3. Distribution of Rotylenchus sp in different coffee agroecologies. ○ = negative sampling sites ▲ positive sampling sites.

Heterodera, to the best of our knowledge, is here offered as the first record of this nematode in Ethiopia. Although species of *Heterodera* occurred in 10% and 8% of the soil samples in wet and dry season, respectively, this genus was specifically recovered only from semi-forest coffee plantations of Bedele region reaching maximum population densities of 3310 juveniles/100 g soil and a prominence value of 233 and 67 in wet and dry seasons respectively (Table 1, Fig. 3; Fig. 4).

Differences were observed in total nematode abundance because of different sampling seasons. The population densities of *Helicotylenchus, Xiphinema* and *Heterodera* were lower in the dry season than the wet season (Table 1). The nematode density of *Scutellonema, Rotylenchus, Tylenchorhynchus, Ditylenchus, Trophorus, Criconemella* and *Hoplolaimus* were similar in both sampling seasons. On the contrary, the population of *Meloidogyne* and *Pratylenchus* were not recovered during the dry season and only rarely recovered in the wet season from Eastern Ethiopia coffee growing regions where most coffee production is declining and replaced by vegetable production. Consistent differences in total plant-parasitic nematode abundance were observed among plantation types with greater abundance in garden coffee than other plantation types. A wide variety of free living nematodes belonging to 8 different families were also observed in all plantation types together with plant-parasitic nematodes. Among these: Dorylaimidae, Cephalobidae and Rhabditidae were found to occur more frequently.

Plant-parasitic nematodes detected in the different coffee growing agroecologies of Ethiopia included species of *Helicotylenchus, Scutellonema, Rotylenchus, Xiphinema, Heterodera Tylenchorhynchus, Ditylenchus, Trophorus, Criconemella, Hoplolaimus, Pratylenchus* and *Meloidogyne. Helicotylenchus* was

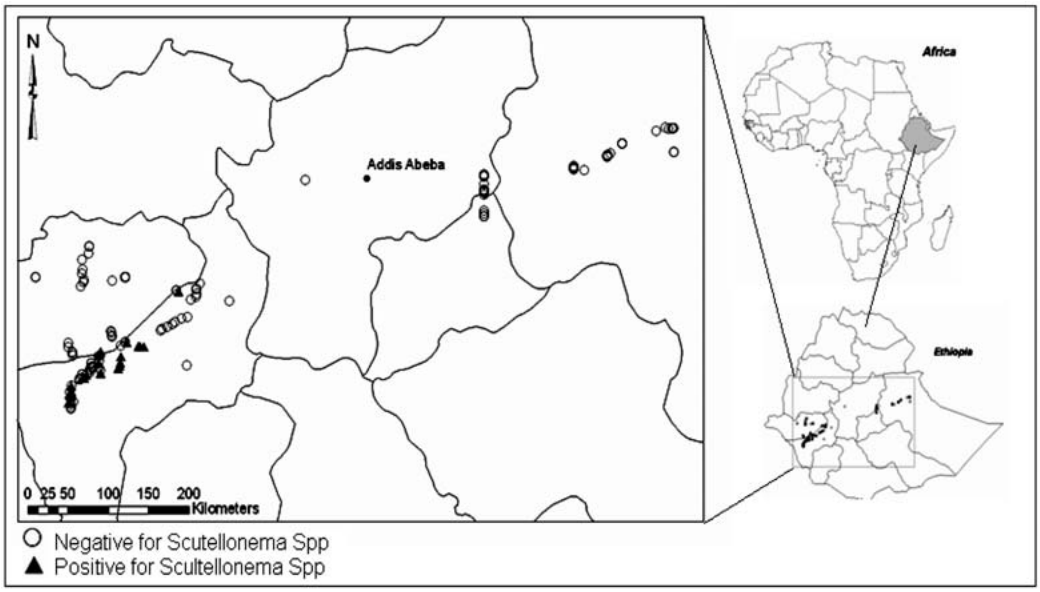

Fig. 4. Distribution of Scutellonema sp in different coffee agroecologies. ○ = negative sampling sites ▲ positive sampling sites.

found to be one of the common nematode genera in coffee plantations of Brazil, USA (Hawaii) and India (Souz *et al.*, 1999; Giribabu and Saha, 2002; Campos and Villain, 2005; Hue *et al.*, 2005).

In our studies, *Helicotylenchus* spp. showed the highest abundance and frequency of all plant-parasitic genera both during the wet and dry season. Although *Helicotylenchus* was not directly isolated from coffee roots, their high abundance even in weed free sampling sites indicate that species of this genus most likely parasitize coffee. At sampling sites with concomitant growth of weeds, it could not be differentiated on which plant *Helicotylenchus* multiplied.

High numbers of *Xiphinema* were also prevalent in weed-free sampling sites suggest parasitism in coffee. Quite interestingly, presence of the *Xiphinema americanum* sensu stricto was restricted to garden coffee plantations. These nematodes are ectoparasites and seldom cause damage to plants. However, they are of considerable importance as vectors for viruses (Sturhan *et al.*, 1997). These species tend to be associated with numerous hosts worldwide (Sturhan *et al.*, 1997; Shurtleff and Averre III, 2000; Kumari *et al.*, 2005, Lamberti *et al.*, 2004) Further studies are necessary to study their importance as a virus vector in coffee.

Species of *Heterodera* were recovered specifically from semi-forest coffee plantations and were all juveniles. Even though never reported on coffee, this genus has world-wide economic importance, detailed research on their distribution, identity and their damage potential in coffee should be studied.

Observations of different species from the genus *Scutellonema, Rotylenchus* and *Tylenchorhynchus*, which generally feed ectoparasitically, revealed low frequency and numbers which do not support economi-

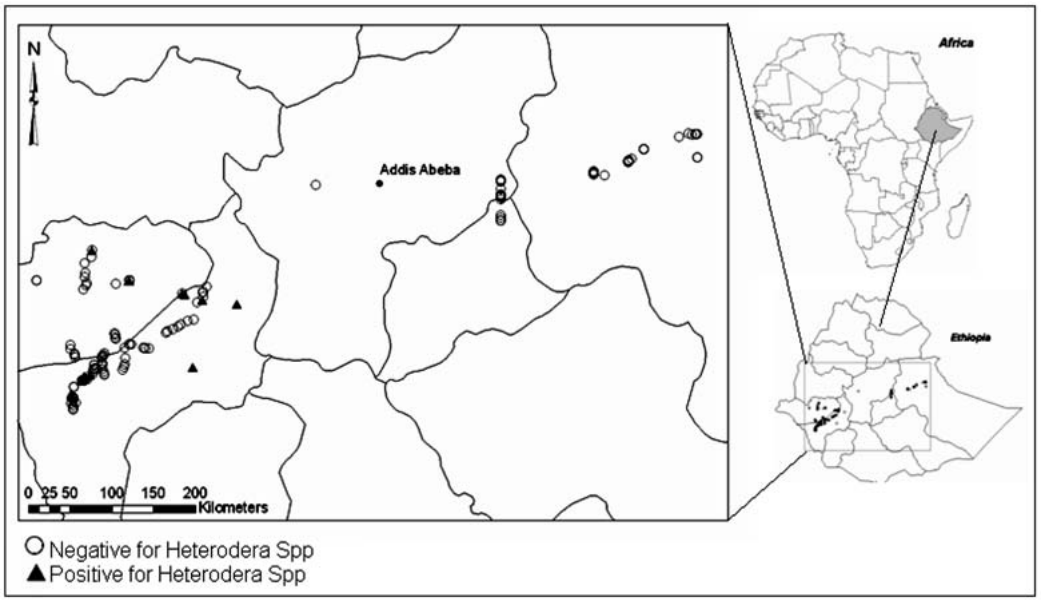

Fig. 5. Distribution of Heterodera sp in different coffee agroecologies. ○ = negative sampling sites ▲ positive sampling sites.

cally important host-parasite relationships with coffee without further study. The potential impact of *Ditylenchus, Trophorus, Criconemella* and *Hoplolaimus* on coffee is also not known. They only were detected in few numbers and sporadically. It is likely that these groups might be associated with the neighboring plant species.

The root-knot nematode *Meloidogyne,* and the root lesion nematodes, *Pratylenchus,* were detected in low numbers and were found only in three and two sampling sites examined respectively in the wet season. Both species were also only recovered as juveniles. It is probable that a host- parasite interrelationship exists between *Meloidogyne* and *Pratylenchus* although it does not seem to be a strong parasitic relationship, based on the low numbers observed at each site and the low frequency of positive sites. Root-knot nematodes known to infect coffee, such as *M. africana, M. decalineata, M. kikuyensis, M. megadora* and *M. exigua* were not detected in our survey. This might be as a result of co-evolution of host-parasite and sources of resistance that may exist in the coffee biodiversity of Ethiopia. As these groups of nematodes are serious pests in coffee growing countries of the world, fields in Ethiopia need to be monitored more closely to determine the presence of these nematodes in other areas and nurseries.

The population of *Helicotylenchus, Xiphinema* and *Heterodera* was lower during the dry season sampling compared with the wet season sampling which strongly indicates their association with wet season plant cover. This could be directly affected by changes in the abiotic environment or indirectly by the effect of abiotic changes on the quantity and quality of the food source, and by interfering with the biotic interactions with other organisms. How-

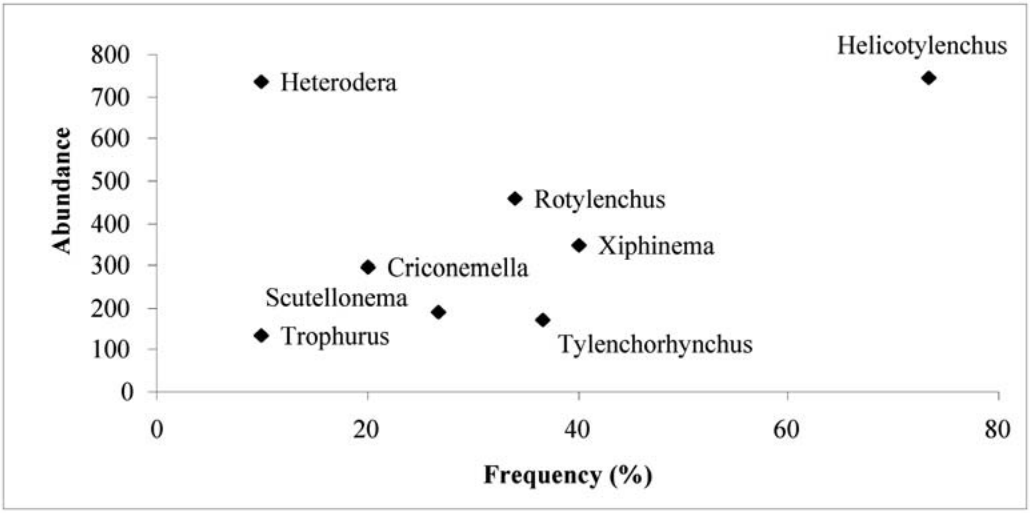

Fig. 6. Frequency and abundance of the major nematode species from rhizosphere of coffee in wet season sampling from Ethiopia.

ever, population densities were often the highest among the nematodes identified in both sampling seasons.

The nematode community of *Scutellonema, Rotylenchus, Tylenchorhynchus, Ditylenchus, Trophorus, Criconemella* and *Hoplolaimus* were relatively abundant and almost similar in both sampling seasons. On the contrary, the population of *Meloidogyne* and *Pratylenchus* were not recovered

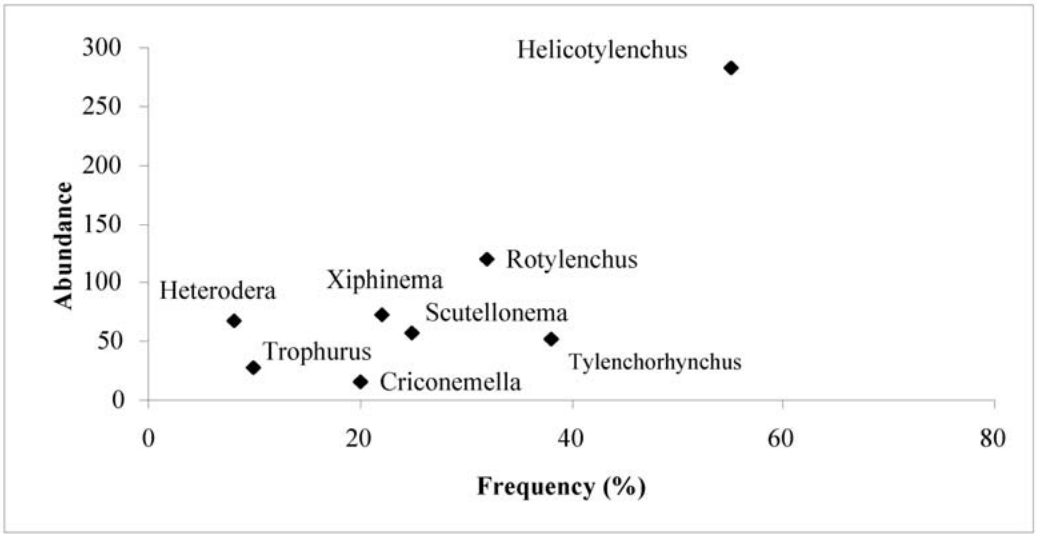

Fig. 7. Frequency and abundance of the major nematode species from rhizosphere of coffee in dry season sampling from Ethiopia.

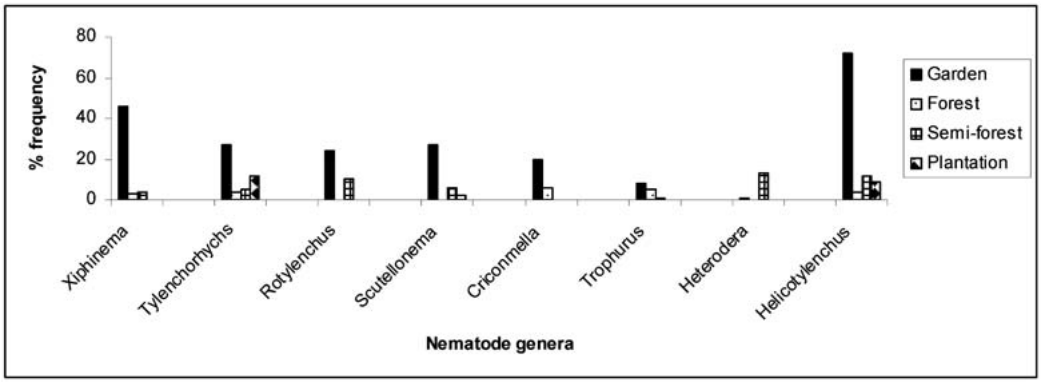

Fig. 8. Frequency of the major plant-parasitic nematode genera in different coffee plantation types during wet season sampling.

during the dry season sampling compared with the rare recovery in wet season recovery.

Few differences were detected in distribution of plant-parasitic nematodes. The notable exception was the presence of *Heterodera* that specifically recovered from semi-forest coffee plantations. Each genus was generally recovered from across the region sampled. Plant-parasitic nematodes were also not detected in the four Eastern Ethiopia coffee growing regions of Sororo, Deder, Chelenko and Harar.

Consistent differences in total plant-parasitic nematode abundance were observed among plantation types with greater abundance in garden coffee than other plantation types. Differences were also observed in total nematode abundance between sampling season. The results revealed some clear seasonal trends in the population dynamics of plant-feeding nematode taxa, which could reasonably be interpreted as changes affected by seasonal environmental factors i.e. soil temperature, soil moisture content as well as ground cover. The seasonal variation in population density could be ascribed to the abiotic especially for nematode species with high nutrient and energy needs such as *Xiphinema*, *Helicotylenchus* and *Tylenchorhynchus* (Norton and Niblack, 1991).

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Received: *4.X.2007*

Recibido:

Accepted for publication: *11.XI.2008*

Aceptado para publicación: