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Plant-parasitic nematodes associated with coffee in Vietnam

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Summary. Roots and soil were sampled in May 2005 from coffee plantations in fifteen localities of the seven coffee producing provinces of Vietnam for the presence of plant-parasitic nematodes on *Coffea arabica* and *C. canephora*. Twenty-one plant-parasitic nematodes species representing 14 genera were recovered from the rhizosphere soil. The endoparasitic nematodes *Rotylenchulus reniformis*, *Meloidogyne* spp., *P. coffeae* and *R. arabocoffeae* were predominant and occurred in 22%, 21%, 27% and 11% of all soil samples with 332, 257, 124 and 61 individuals/250 cm^3 soil, respectively. *Pratylenchus coffeae*, *R. arabocoffeae* and *Meloidogyne* spp. were found in 24%, 9% and 12% of all root samples, respectively. *Pratylenchus coffeae* was present in root samples from 11 of the 15 localities, while *Meloidogyne* occurred in root samples from 9 localities but was present in soil samples from 12 localities. Root-knot nematodes were not found in root and soil samples from the Northern region (Muong Ang and Son La) and Dak Doa. *Radopholus arabocoffeae* was not detected in samples from localities from Northern and Centre of Vietnam, but was only present in some of the Western Highlands localities. Plant-parasitic species recorded for the first time in Vietnam in association with coffee were *Hoplolaimus chambus*, *Xiphinema elongatum*, *Diphterophora perplexans*, *Apratylenchus vietnamensis* and *A. binhi*. The occurrence of the main nematode genera varied across clusters of soil texture. Samples with high numbers of *Meloidogyne* spp. were grouped in clay soils, whereas *R. arabocoffeae* occurred in sandy and loamy soils indistinctively. *Pratylenchus* spp. and *R. reniformis* were present in large numbers in sandy soils.

Key words: *Coffea arabica*, *Coffea canephora*, endoparasitic nematodes, soil characteristics, plant age.

To date, 80 species of coffee have been described of which only two are of economic importance, *viz. Coffea arabica* (Arabica coffee) and *C. canephora* (Robusta coffee) (Campos & Villain, 2005). The production of *C. arabica* accounts for 75% of world exports and is produced in 60 countries, with the highest production in South and Central America and in East and Central Africa. Brazil, however, produces more than 40% of the world's Arabica coffee. *Coffea canephora* is produced mostly in West Africa and South Asia, with Vietnam being the main Robusta coffee producer accounting for 40% of the world's production (Marsh, 2007).

The first coffee trees were introduced to Vietnam in 1857, while the first coffee plantations were established in church communities in the provinces of Ninh Binh and Quang Binh in 1888 (Doan *et al.*, 2000). Although coffee growing areas are distributed in the Western Highland, the Central region and the Northern highlands of Vietnam, the primary area for coffee production is concentrated in the Western highland provinces (Doan *et al.*, 2000). The Western highland provinces account for 85% of Vietnam's total coffee production area. Robusta coffee and Arabica coffee (mainly cv. Catimor) account for approximately 90% and 10% of the production area in Vietnam, respectively. The coffee growing area in North Vietnam increased from *ca* 3000 ha in 1975 to 495000 ha in 2007 (http://faostat.fao.org).

Plant-parasitic nematodes are a major limiting factor in coffee producing areas worldwide (Campos & Villain, 2005). *Meloidogyne* (root-knot nematodes) and *Pratylenchus* (root lesion nematodes) are the predominant genera and are widely distributed in coffee plantations, causing

great economic losses to both farmers and industry (Villain, 1991; Bertrand *et al.*, 1995; Campos & Villain, 2005). Many other genera, however, have also been found associated with coffee trees worldwide (Campos & Villain, 2005). In Vietnam, information regarding plant-parasitic nematode species associated with coffee is limited. The few published preliminary studies focus on nematodes associated with Robusta coffee and concern surveys conducted in the Western Highlands and the North of Vietnam (Nguyen & Nguyen, 2001; Phan *et al.*, 2001; Duong *et al.*, 2004), as well as in the Ben Tre, Tien Giang and Hau Giang provinces (Nguyen *et al.*, 1990). The report published by Phan *et al.* (1976) is the only on Arabica coffee. Only Phan *et al.* (2001) examined nematodes in the roots. Recently, Nguyen & Nguyen (2001) and Duong *et al.* (2004) reported the presence of *Radopholus similis* in coffee samples from the Western Highlands. However, Trinh *et al.* (2004) did not confirm the above report.

At present Arabica coffee production is expanding in Vietnam which will result in better balance between both species, thereby increasing the farmers' profits. To obtain information on potentially harmful plant-parasitic nematodes associated with both coffee species, both in soil and in roots, we conducted an extensive survey in the coffee production areas of the country. We report on the nematode species that were detected and on the link between their presence and soil characteristics and plant age.

MATERIAL AND METHODS

Fifteen localities (Fig. 1) in seven provinces representative of the coffee production areas of Vietnam were sampled in May 2005. The number of localities (districts) sampled per province was determined as a function of the importance (surface planted) of the coffee crop. In each locality, five coffee farms were randomly selected for sampling. On each of the selected farms, the coffee species and history of the crop was recorded and root and soil samples were taken from five randomly selected coffee trees. The samples were taken from the top 20 cm of weed-free soil from three different places under the tree canopy at a distance of about 50-70 cm from the stem. As a result, a total of 375 individual (375 root and 375 soil) samples, each weighing at least 1000 g, were collected.

Nematodes were extracted from 250 cm^3 subsamples of the mineral soil fraction by sieving and decanting (Cobb, 1918). After decanting, the sediment was transferred onto a 75µ-sieve placed in a Petri dish (90-mm diam.) and left for still filtering for 48 h at room temperature (Nguyen and Nguyen, 1993). Nematodes were extracted from thoroughly washed 5 g roots using the maceration and sugar centrifugal-flotation method (Coolen & D'Herde, 1972). Nematode numbers were determined in a counting dish under a stereomicroscope and expressed per 250 cm^3 soil or 5 g roots. For species identification, nematode suspensions from each sample were fixed with hot TAF solution (Courtney *et al.*, 1955). Nematodes were subsequently transferred to anhydrous glycerin and mounted on slides by the paraffin ring method (De Grisse, 1969). Species were eventually identified by means of morphology and morphometrics. Since the genus *Meloidogyne* was rarely represented by adults, root-knot nematode populations were seldom identified up to species level. Prominence values (PV= population density $\times$ (frequency of occurrence)$^{1/2}$ $\times$ 10^{-1}) were calculated for each species (Fourie *et al.*, 2001). Soil properties (soil type, organic matter content and pH) were determined for each locality sampled (Van Reeuwijk, 2002).

The influence of both soil characteristics and species of coffee on the occurrence of the most dominant nematode genera, *viz. Meloidogyne* spp., *Pratylenchus* spp., *Radopholus arabocoffeae* and *Rotylenchulus reniformis* was examined by means of a two separated k-mean cluster analyses. We first reduced the size of the original data matrix by obtaining the average number for each nematode genus and soil parameter at all sampling locations. Then a v-fold-cross-validation algorithm was implemented to assess the optimal number of clusters within the set of data according to the variables analyzed. Subsequently, the k-means cluster analysis was implemented using the statistical package *Statistica* 8.0 and applying the default settings. Differences in nematode numbers and soil parameters according to soil texture or coffee species were obtained after pair wise cluster comparisons using the Mann-Whitney U-Test.

RESULTS

Except for localities in the Nghe An province (78 m above sea level), all of the sampled areas were situated at medium to high altitude (442 to 1432 m above sea level) (Table 1). All soil samples had a low pH ranging between 4.06 and 5.40. Soils from the Western highland, Khe Sanh (Quang Tri Province), and Nghia Dan (Nghe An Province) were classified as basalt soils, while other soils were classified as fluvisoils (Pearce, 1996). The

texture of the sampled soils varied between sandy loam (clay content: 6.6 - 22.2%) and heavy clay (48.6 - 53.4%). The lowest organic matter content (2.1%) was found in samples from Muong Ang (Dien Bien Province); the highest concentration was detected in samples originating from the Western Highlands (3.2- 3.7%).

Plant-parasitic nematodes were detected in 327 out of the 375 collected root samples and in all 375 soil samples. From these latter samples 21 species representing 14 genera were recovered (Table 2). Nematodes recorded from soil samples were predominantly endoparasitic species, *viz. R. reniformis*, *Meloidogyne* spp., *P. coffeae* and *R. arabocoffeae*. These species occurred in 22, 21, 27 and 11% of all soil samples at an average of 332, 257, 124 and 61 individuals per 250 cm^3 soil, respectively. Other endoparasitic nematodes were present at low densities and low frequency levels *viz. P. brachyurus* and two species of a new genus *Apratylenchus*, *viz. A. vietnamensis* and *A. binhi* (Trinh *et al.*, 2009). Ectoparasitic species identified from soil samples were mainly represented by *Xiphinema diffusum*, *Helicotylenchus dihystera* and *Macroposthonia magnifica*. These latter species occurred in 31, 27 and 11% of the samples, with average population densities of 15, 38 and 13 individuals per 250 cm^3 soil, respectively. Other ectoparasites found were *Macroposthonia rustica*, *Diphterophora perplexans*, *Discocriconemella limitanea*, *Helicotylenchus cavenessi*, *H. rotundicauda*, *H. coffeae*, *Hemicriconemoides mangiferae*, *Hoplolaimus chambus*, *Longidorus* sp., *Xiphinema brasiliense* and *X. elongatum*.

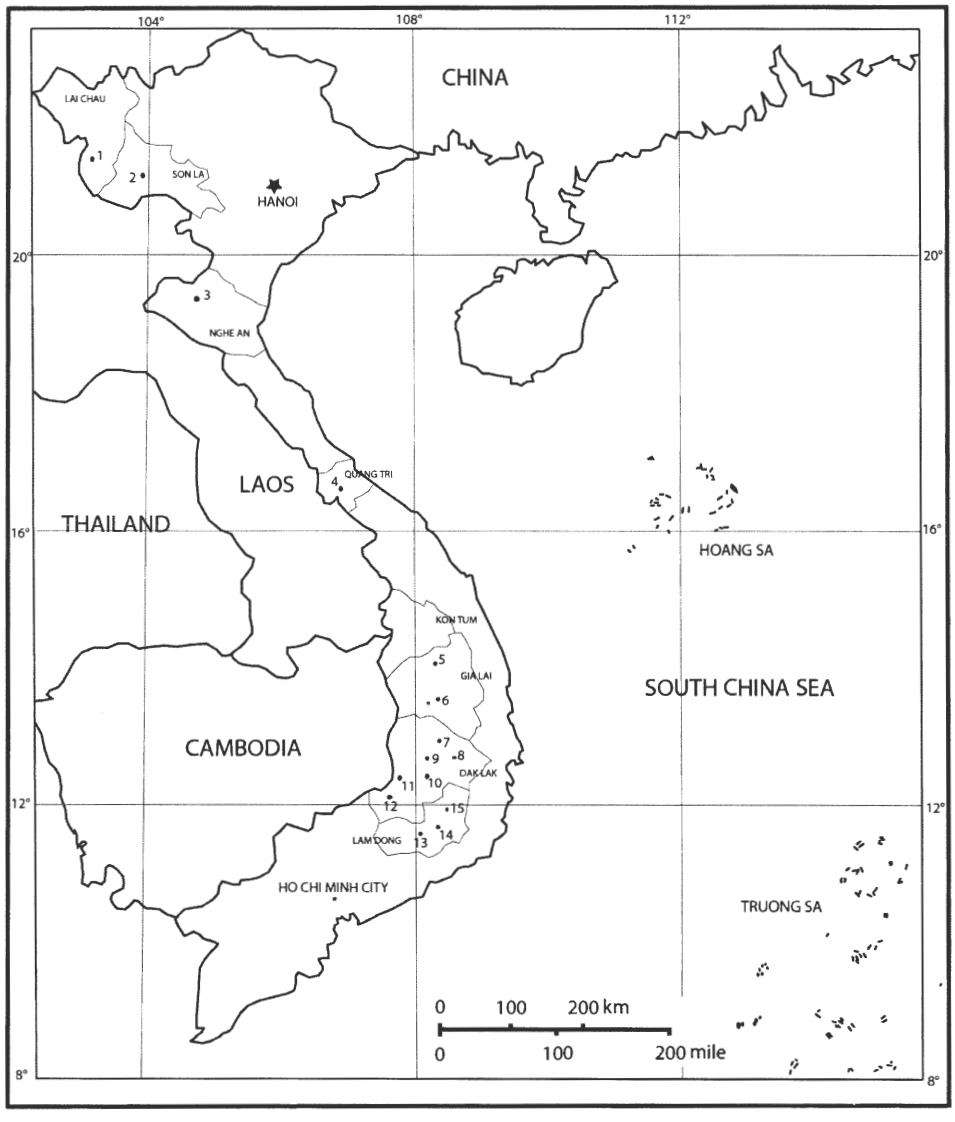

Fig. 1. Localities where coffee fields were sampled for plant-parasitic nematodes in Vietnam.

Table 1. Altitude and soil properties in sampling sites in Vietnamese coffee plantations.

Region	Locality (District, Province)	Altitude (meters above sea level)	Soil texture	Clay (%)	Organic mater (%)	pH (H_20)	Coffee species and age of sampled trees (years)	
							Arabica	Robusta
North	Muong Ang, Dien Bien	601	Sandy loam	8.16	2.06	5.40	4-5	–
	Son La, Son La	761	Sandy clay loam	15.04	2.80	4.75	4-5	–
Center	Nghia Dan, Nghe An	78	Sandy loam	8.14	2.36	4.60	4	12
	Khe Sanh, Quang Tri	520	Sandy clay loam	24.66	2.99	4.40	4	–
Western Highland	Dak Doa, Gia Lai	702	Sandy loam	9.78	2.68	4.30	4	10
	Chu Se, Gia Lai	469	Loamy sand clay	21.02	2.73	4.75	–	10-12
	Krong Nang, Dak Lak	906	Sandy loam	7.36	2.21	4.85	4-5	9-10
	M'drak, Dak Lak	474	Sandy loam	8.64	2.58	4.05	4	–
	Buon Ma Thuot, Dak Lak	512	Clay	53.44	2.28	4.25	–	10-12
	Krongana, Dak Lak	442	Sandy loam	14.92	2.84	4.95	–	3-15
	Dak Song, Dak Nong	907	Sandy loam	6.56	3.74	4.05	3	8
	Dak Lap, Dak Nong	686	Clay	48.64	2.98	4.50	4	–
	Di Linh, Lam Dong	977	Sandy loam	22.18	3.24	5.00	–	8
	Da Lat, Lam Dong	1432	Clay	53.24	2.98	4.55	5	–
	Lam Ha, Lam Dong	843	Sandy clay loam	16.60	3.24	3.80	4	7

DISCUSSION

Our survey yielded an extensive list of both endoparasitic and ectoparasitic plant nematodes as parasites of coffee. Most of the detected species were already recorded during previous surveys in Vietnam and/or in other countries. However, two species, *viz. A. vietnamensis* and *A. binhi* were detected for the first time and described recently (Trinh *et al.*, 2009). Other species, *viz. H. chambus*, *X. elongatum* and *D. perplexans* were detected for the first time on coffee in Vietnam.

The root lesion nematodes were represented by two species, *viz. P. coffeae* and *P. brachyurus*. *Pratylenchus* species are among the most commonly observed and destructive nematodes on coffee (Lordello, 1986; Wrigley, 1988; Campos & Villain, 2005). *Pratylenchus coffeae*, initially described on coffee in Java by Zimmermann (1898), is still the most widely reported species of root lesion nematodes in coffee worldwide. Both, *P. brachyurus* and *P. coffeae* are parasitic on coffee and although generally less harmful than *M. incognita*, they can cause important yield losses (Kumar & Samuel, 1990). Other species of the genus *Pratylenchus* that parasitize coffee are *P. goodeyi, P. loosi, P. panamaensis, P. pratensis, P. vulnus* and *P. zeae* (Siddiqi *et al.*, 1991; Golden *et al.*, 1992; Campos & Villain, 2005). *Pratylenchus brachyurus* is the only root-lesion species known to infect coffee in South America (Lordello, 1972). The species has been found in many regions in Brazil and to date is the most widely distributed root lesion nematode in this country (Campos & Lima, 1986). *Pratylenchus brachyurus* was reported from coffee in 17 Asian countries (Anonymous, 2003); the species was earlier reported in Vietnam in groundnut (Sharma *et al.*, 1994). As a result of their restricted survey in Vietnamese coffee soils, Nguyen and Nguyen (2001) reported five *Pratylenchus* species (*P. brachyurus, P. coffeae, P. delattrei, P. neglectus* and *P. penetrans)*. However,

Table 2. Prominence value (PV), frequency of occurrence (%) and mean population density of the predominant plant-parasitic nematode species recovered from soil samples (250 cm^3) from the rhizosphere and from coffee roots (5g) of coffee trees from 15 coffee localities in Vietnam

Nematode species	Soil			Root		
	PV	Frequency of occurrence (%)	Mean population density	PV	Frequency of occurrence (%)	Mean population density
Rotylenchulus reniformis	155	22	332	6	1	61
Meloidogyne spp.	118	21	257	30	12	88
Pratylenchus coffeae	65	27	124	122	24	248
Radopholus arabocoffeae	20	11	61	49	9	162
Helicotylenchus dihystera	20	27	38	1	1	13
Xiphinema diffusum	8	31	15	–	–	–
Pratylenchus brachyurus	4	2	25	5	2	37
Macroposthonia magnifica	4	11	13	–	–	–
Discocriconemella limitanea	4	4	20	–	–	–
Helicotylenhus rotundicauda	4	1	39	–	–	–
Hemicriconemoides mangiferae	3	3	19	–	–	–
Diphterophora perplexans	2	2	14	–	–	–
Xiphinema elongatum	2	1	18	–	–	–
Helicotylenchus cavenessi	2	1	18	–	–	–
Paratylenchus nawadus	2	1	16	3	1	29
Hoplolaimus chambus	4	1	35	–	–	–
Apratylenchus spp.	1	2	5	4	2	28
Macroposthonia rustica	1	1	7	–	–	–
Helicotylenchus coffeae	1	1	14	–	–	–
Longidorus sp.	1	1	2	–	–	–
Xiphinema brasiliense	1	1	5	–	–	–

Phan *et al.* (2001) and Tran (2002) only reported the occurrence of and damage caused by *P. coffeae* on Robusta coffee in the western highland in Vietnam.

The burrowing nematode, *R. similis*, was reported by Zimmermann (1898) on coffee in Java; the author considered this nematode the most harmful nematode to coffee in that country and second only in importance to *P. coffeae*. Also, other authors reported the importance of *R. similis* (e.g. Kurma *et al.*, 1980). The presence of *R. similis* in Vietnam was reported previously by Nguyen & Nguyen (2001) and Duong *et al.* (2004) but we were unable to confirm its presence either

in the present work or in a previous survey (Trinh *et al.*, 2004). When describing *R. arabocoffeae*, Trinh *et al.* (2004) reported this species on Arabica coffee; it clear from the present survey that the species is also present on Robusta coffee. We detected *R. arabocoffeae* in 9% of the sampled localities. It was absent in the localities from the North and Centre; in the Western Highlands it was not only important in Krong Nang where it was first reported, but also in Dak Doa, M'drak, Dak Lap, Dak Song and Di Linh. In 2001, *R. duriophilus* was detected in a coffee field in Krongana-Dak Lak (Nguyen *et al.*, 2003, Trinh *et al.*, 2004) but this species was not found in the present survey.

Root-knot nematodes are more widely distributed throughout the world in coffee plantations than any other major group of parasitic nematodes. To date 17 species of *Meloidogyne* are reported on this crop (Campos & Villain, 2005). During our survey, *M. incognita* was identified in some localities; however, specific galls caused by root-knot nematodes were not found. Additional *Meloidogyne* populations were extracted from coffee roots. Unfortunately, because of the lack of females, these populations could not be identified. Also, for these populations we did not observe galls on the host roots. Second-stage juveniles of *Meloidogyne* were quite abundant in many soil samples. During a survey, Nguyen and Nguyen (2001) found *M. incognita* in the Western Highlands and reported the absence of root-knot nematodes in the North and Centre of Vietnam. *Meloidogyne coffeicola, M. paranaensis and M. incognita* caused peeling and cracking of roots but did not produce typical galls in coffee, whereas *M. exigua* caused typical galls easy to recognize in the field (Campos & Villain, 2005). Further research should elucidate the species identity of the Vietnamese root-knot nematodes on coffee.

Although ecto- and semi-endoparasitic nematodes are reported associated with coffee by many surveys, they are considered of minor importance to coffee (Souza, 2008). However, *R. reniformis* is reported to cause damage to coffee in India (Anonymous, 1966), the Philippines (Valdez, 1968), in Brazil (Lordello, 1980), in New Guinea, Fiji and Western Samoa (Bridge *et al.*, 1988). In our survey, *R. reniformis* was frequently present. Sometimes the species was detected at high densities in the soil (Krong Nang); in root samples individuals were found frequently but at low densities. Nguyen and Nguyen (2001) reported more than 500 individuals/250 cm^3 soil in Nghe An province. The same authors reported the presence of 12 *Helicotylenchus* species on coffee; with this high number, the genus demonstrated the richest diversity. During this survey, however, we detected only four species representing this genus (*H. dihystera*, *H. rotundicauda*, *H. cavenessi* and *H. coffeae*); only *H. dihystera* was found in roots.

Even though ectoparasite nematodes like *Helicotylenchus*, *Discocriconema*, *Hoplolaimus*, *Dipterophora*, *Xiphinema*, *Macroposthonia* and *Longidorus* species can be associated with weeds or intercrops (Souza, 2008), our observations in weed-free environments provide evidence that these species are obligate parasites of coffee.

The *Heterodera* species earlier reported from Lai Chau by Nguyen & Nguyen (2001) was not found in this survey. Probably, the species has a very local distribution. In Krong Ana we observed

Table 3. Prominence value (PV), frequency of occurrence (%) and mean population density of the three dominant plant-parasitic nematodes genera and species recovered from root samples (5 g) of two coffee species in Vietnam.

Coffee species and age of sampled trees (years)	*Pratylenchus coffeae*			*Meloidogyne* spp.			*Radopholus arabocoffeae*		
	PV	Frequency of occurrence (%)	Mean population density	PV	Frequency of occurrence (%)	Mean population density	PV	Frequency of occurrence (%)	Mean population density
C. arabica cv. Catimor (Arabica coffee) < 5	167	18	393	24	15	63	55	10	174
C. canephora (Robusta coffee) < 5	7	1	74	2	1	15	–	–	–
5-10	65	15	167	10	5	44	22	4	110
>10	58	21	126	45	6	182	24	2	168

Table 4. Prominence value (PV), frequency of occurrence (%) and mean population density of the three dominant nematode genera and species recovered from root samples (5g) of coffee trees from 15 localities in Vietnam.

Localities (District, Province)	*Pratylenchus coffeae*			*Meloidogyne* spp.			*Radopholus arabocoffeae*		
	PV	Frequency of occurrence (%)	Mean population density	PV	Frequency of occurrence (%)	Mean population density	PV	Frequency of occurrence (%)	Mean population density
Muong Ang, Dien Bien	–	–	–	–	–	–	–	–	–
Sơn La, Son La	–	–	–	–	–	–	–	–	–
Nghia Dan, Nghe An	597	92	622	72	24	146	–	–	–
Khe Sanh, Quang Tri	2	4	12	–	–	–	–	–	–
Dak Doa, Gia Lai	80	36	133	–	–	–	103	28	195
Chu Se, Gia Lai	69	30	126	61	36	102	–	–	–
Krong Nang, Dak Lak	76	56	101	27	24	57	107	44	161
M'drak, Dak Lak	–	–	–	29	44	43	96	28	182
Buon Ma Thuot, Dak Lak	154	56	207	–	–	–	–	–	–
Krongana, Dak Lak	56	44	85	72	12	209	–	–	–
Dak Song, Dak Nong	19	4	95	23	16	57	41	12	117
Dak Lap, Dak Nong	48	12	139	127	84	139	29	8	102
Di Linh, Lam Dong	8	4	42	–	–	–	37	16	92
Da Lat, Lam Dong	–	–	–	10	16	24	–	–	–
Lam Ha, Lam Dong	44	20	98	2	8	7	–	–	–

Table 5. Mean values for different nematode genera and soil parameters after a K-means cluster analysis and subsequent Mann-Whitney U-Test between obtained clusters. Asterisks indicate significant differences at P≤0.05 within each variable.

Soil texture								
Cluster	Type	*Meloidogyne* spp.	*Pratylenchus* spp.	*Radopholus arabocoffeae*	*Rotylenchulus reniformis*	% Clay	% OM	pH
Cluster 1	Loamy	26.5	37.8	19.4	13.9	15.2	2.9	4.4
Cluster 2	Clay	69.8	57.4	3.4	6.8	51.7*	2.7	4.4
Cluster 3	Sandy	7.9	329.4*	41.5	333.6*	7.8	2.1*	4.9*
Cultivar								
Cluster 1	Arabica	30.6	119.9*	20.6	115.6*	21.1	2.6	4.5
Cluster 2	Robusta	33.6	61.4	19.9	6.7	21.3	2.9	4.5

frequently mosaic symptoms on coffee leaves; *X. diffusum* which was present at high densities seems to be associated with this foliar disease.

All three dominant endoparasitic nematode species, *viz. P. coffeae, R. arabocoffeae* and *Meloidogyne* spp. were present in the roots of both coffee species. Because on 5-year-old Arabica coffee higher numbers of these species were found than on Robusta coffee and because *R. arabocoffeae* was even absent in roots of Robusta

younger than 5 years, it can be concluded that Arabica coffee is a better host for these species. Nevertheless, Robusta coffee still should be considered a good host because both frequencies of occurrence and population densities of these nematodes increased with increasing age of the plants. When present, these three endoparasitic species most frequently were present simultaneously, either in pairs or sometimes all three together. Apparently, these species do not show great antagonism to each other. It might be interesting to examine their interaction in more detail.

The occurrence of the main nematode genera varied across clusters of soil texture. Samples with high numbers of *Meloidogyne* spp. were grouped in clay soils, whereas *R. arabocoffeae* occurred in both sandy and loamy soils. *Pratylenchus* spp. and *R. reniformis* were present in large numbers in sandy soils. The influence of soil characteristics on plant-parasitic nematodes is well documented. Endo (1959) reported that *P. brachyurus* reproduced better on strawberry and cotton grown in sandy loam soil than in clay loam, loam or sandy soils, indicating that soil texture does affect activity of this nematode. By contrast, no correlation was found between *P. brachyurus* and soil particle size in cotton fields in Brazil (Asmus, 2004). *Meloidogyne* spp. and the ectoparasitic species such as *Xiphinema* spp. were found associated with light andosols (Cadet & Thioulouse, 1998); *Aorolaimus luci* needed, in addition, higher levels of organic matter. *Pratylenchus coffeae* occupied any type of soil rich in organic matter and its abundance seemed influenced by calcium and magnesium content or pH. By contrast, *P. brachyurus* did not appear to be sensitive to any of the measured physico-chemical soil characteristics. Kinloch and Sprenkel (1994) reported that in cotton fields in Florida the distribution of juveniles of *Meloidogyne* spp. was not influenced by soil type. However, *R. reniformis* was more prevalent in the heavier soils.

Symptoms of coffee decline caused by both *R. arabocoffeae* and *P. coffeae* were frequently observed on Arabica coffee in Krong Nang, M'drak, Dak Lap and on Robusta coffee in Dak Song, Dak Doa, Di Linh. Decline caused by *P. coffeae* was observed in Nghia Dan and Buon Ma Thuot. Since at most of these localities the soil texture was sandy loam, the decline may be associated with the lighter soil type.

Vietnamese coffee growers either produce Arabica plants themselves or obtain them from nurseries. Robusta coffee seedlings are grafted on *C. excelsa* or other rootstocks. We did not find plant-parasitic nematodes in nurseries during this survey. Growers as well as nurseries disinfect the growing medium by solarisation. Because nematodes are not introduced in the production fields with the young plants, the nematodes were probably present in the soil before the coffee was planted. In most of the fields coffee is planted in areas where natural forest vegetation had been removed. Major and common components of that natural forest were wild bananas (Nguyen *et al*, 1997). That might explain the predominance of *P. coffeae* in Vietnamese coffee production.

The perennial character of coffee makes the control of plant-parasitic nematodes in this crop difficult. Increasing concern about environmental contamination by pesticides necessitates the development of non-chemical strategies to overcome the negative impact in Vietnam of species like *P. coffeae* and *R. arabocoffeae*. Pre-planting sampling strategies should predict the impact of the nematode population on the following crop and enable preventive measures to be taken. In infected fields, the spread of the nematodes might be controlled by destroying nematode infected coffee plants and weeds. The existence of plant resistance or tolerance to these nematodes should be examined. Biological control strategies (e.g. *Tagetes* spp. and non-pathogenic *Fusarium oxysporum*) might further reduce the impact of the nematodes on the crop (Souza, 2007).

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P. Q. Trinh, E. de la Peña, C. N. Nguyen, H. X. Nguyen and M. Moens. Фитопаразитические нематоды кофе во Вьетнаме.

Резюме. С целью выявления фитонематод на кофе видов *Coffea arabica* и *C. canephora* образцы корней и почвы были собраны в мае 2005 с 15 кофейных плантаций в 7 регионах выращивания кофе во Вьетнаме. В ризосфере корней кофе были выявлены представители 21 вида фитопаразитических нематод из 14 родов. Эндопаразитические нематоды видов *Rotylenchulus reniformis*, *Meloidogyne* spp., *P. coffeae* и *R. arabocoffeae* доминировали и присутствовали соответственно в 22%, 21%, 27% и 11% из всех проб почвы с численностью 332, 257, 124 и 61 особей на 250 см^3 почвы. *Pratylenchus coffeae*, *R. arabocoffeae* и *Meloidogyne* spp. были обнаружены в 24%, 9% и 12% образцах проб, соответственно. *Pratylenchus coffeae* присутствовали в пробах почвы в 11 из 15 изученных плантаций, тогда как *Meloidogyne* были отмечены в пробах корней из 9 плантаций и в пробах почвы из 12 плантаций. Галлообразующие нематоды не были обнаружены в пробах почвы и корней в северном регионе выращивания кофе (Мыонг Ан и Шон Ла), а также в Дак Доа. *Radopholus arabocoffeae* не был выявлен в пробах из северного и центрального Вьетнама и встречался лишь на некоторых плантациях на Центральном Плато. *Hoplolaimus chambus*, *Xiphinema elongatum*, *Diphterophora perplexans*, *Apratylenchus vietnamensis* и *A. binhi* представляют собой виды фитопаразитических нематод, впервые отмеченных на кофе во Вьетнаме. Встречаемость основных родов нематод существенно отличалась на почвах разных типов. Образцы с высокой встречаемостью *Meloidogyne* spp. были обычны для глинистых почв, тогда как *R. arabocoffeae* встречался как на песчаных почвах, так и на суглинках. *Pratylenchus* spp. и *R. reniformis* в больших количествах встречались в песчаных почвах.