RESEARCH/INVESTIGACIÓN

PLANT-PARASITIC NEMATODES ASSOCIATED WITH BLACKBERRY (*RUBUS ADENOTRICHUS* SCHLTDL.) PLANTATIONS IN COSTA RICA

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ABSTRACT

Peraza-Padilla, W., and M. Orozco-Aceves. 2018. Plant-parasitic nematodes associated with blackberry (*Rubus adenotrichus* Schltdl.) plantations in Costa Rica. Nematropica 48:145-154.

In this study, plant-parasitic nematodes associated with blackberry plantations in Costa Rica were determined. From 2005 to 2014, 12 samples of roots and 36 samples of soil from blackberry plantations were collected in nine localities, and nematodes were extracted and identified to genus and some to species. Eighteen different genera of nematodes; plant-parasitic and other nematodes associated with roots; were identified these are: *Aphelenchoides*, *Aphelenchus*, *Criconema*, *Criconemoides*, *Crossonema*, *Ditylenchus*, *Helicotylenchus*, *Hemicycliophora*, *Heterodera*, *Meloidogyne*, *Scutellonema*, *Pratylenchoides*, *Pratylenchus*, *Psilenchus*, *Trichodorus*, *Tylenchorhynchus*, *Tylenchus*, and *Xiphinema*. Endoparasitic nematodes of importance like *Meloidogyne* sp. and *Pratylenchus* sp. were found in nine counties and three localities, respectively. The highest abundance of plant-parasitic nematodes of second-stage juveniles of *Meloidogyne* sp. was found in La Trinidad and San Martín. In La Luchita, Bajo Canet, Páramo, and Jardín high population densities of spiral nematodes of the genus *Helicotylenchus* were observed. Additionally, four species within the Criconematidae family (ring nematodes) were identified for the first time in association with blackberry in the country; these are *Crossonema civellae*, *Criconema neopacificum*, *C. graminicola*, and *Criconemoides lizarbus*.

Key words: dagger nematode, ring nematodes, root-knot nematode, spiral nematodes, stubby-root nematode

RESUMEN

Peraza-Padilla, W., y M. Orozco-Aceves. 2018. Nematodos parásitos de plantas asociados con plantaciones de mora (*Rubus adenotrichus* Schltdl.) en Costa Rica. Nematropica 48:145-154.

En este estudio se determinaron los nematodos fitoparásitos asociados a plantaciones de mora en Costa Rica. De 2005 a 2014, se recolectaron doce muestras de raíces y 36 muestras suelo de plantaciones de mora en nueve localidades, se extrajeron los nematodos y se identificaron a nivel de género y algunos a nivel de especie. En total se identificaron 18 géneros diferentes, incluyendo nematodos fitoparásitos y otros nematodos asociados a raíces, estos son: *Aphelenchoides*, *Aphelenchus*, *Criconema*, *Criconemoides*, *Crossonema*, *Ditylenchus*, *Helicotylenchus*, *Hemicycliophora*, *Heterodera*, *Meloidogyne*, *Scutellonema*, *Pratylenchoides*, *Pratylenchus*, *Psilenchus*, *Trichodorus*, *Tylenchorhynchus*, *Tylenchus* y *Xiphinema*. Nematodos endoparásitos de importancia como *Meloidogyne* sp. y *Pratylenchus* sp. fueron encontrados en nueve y tres localidades respectivamente. La mayor cantidad de juveniles de segundo estadío de *Meloidogyne* sp. fue encontrada en La Trinidad y San Martín. En La Luchita, Bajo Canet, Páramo y Jardín,

se observaron altas densidades poblacionales de nematodos espirales del género *Helicotylenchus*. Además, cuatro especies de la familia Criconematidae (nematodos anillados) fueron identificadas por primera vez en asociación con plantas de mora en el país; estos son *Crossonema civellae*, *Criconema neopacificum*, *C. graminicola* y Criconemoides lizarbus.

Palabras clave: nematodo anillado, nematodo daga, nematodo espiral, nematodo nodulador, nematode raíz escoba de bruja

INTRODUCTION

The presence of plant-parasitic nematodes in agricultural soils is a limiting factor for blackberry production worldwide because these organisms result in yield decreases, and consequently, economic losses to farmers. However, qualitative and quantitative information regarding plant-parasitic nematodes associated with blackberry is limited in Costa Rica.

Blackberry was once considered a wild fruit, but now it is intensively cultivated in several countries as Australia, Argentina, Canada, Colombia, Spain, France, Guatemala, and Switzerland (Strik *et al*., 2007; Clark and Finn, 2014). Blackberry has become a popular fruit that is consumed as fresh fruit or as processed products like juices, concentrated flavors, jams, jellies, or confectionary products (CCI, 1999; Tafur *et al*., 2006). For this reason, the market demand for blackberries has increased dramatically during recent years. The area under blackberry production increased 45% during 2005 (20,035 ha) as compared with 1995, which represented a production of 154,644 tons (Strik *et al*., 2007). In international markets, blackberries are sold mainly for food processing to accentuate flavors and aromas (CCI, 1999; Tafur *et al*., 2006).

In Central America, blackberry is produced in Costa Rica and Guatemala. The total area dedicated to production in both countries is 1640 ha, and the majority of the area (1550 ha) is located in Costa Rica. Within Costa Rica, blackberry is produced in the provinces of San José and Cartago (Strik *et al*., 2007). The major planting areas are located in Los Santos area (Tarrazú, Dota, León Cortés), in El Guarco, and in the upper part of Perez Zeledón. These areas are located at elevations of 1,400-2,500 masl. In the past, blackberry plantations were managed as low-input systems, but during the last decade, a more intensive management using technological approaches has been implemented. To date in Costa Rica, blackberry is cultivated as a perennial crop, allowing year-round production, with production peaks between March and April (Cerdas and Montero, 1992). The most popular blackberry varieties cultivated in Costa Rica are the so called "wine" and "criolla". In the country, blackberry plantations can be managed either as organic (certified) or conventional.

Intensive management of blackberry production has stimulated the presence of plant-parasitic nematodes, but there are only a few studies describing the plant-parasitic nematodes associated with blackberry plants (i.e., roots). A study conducted in the USA reported 21 species of plant-parasitic nematodes associated with blackberry, such as *Xiphinema americanum*, *Helicotylenchus paraplatyurus*, *H. platyurus*, *H. pseudorobustus*, *Pratylenchus vulnus*, *P. zeae*, *Criconemella axeste*, *C. curvata*, *C. denoudeni*, *C. ornata*, *C. shaerocephala*, *C. xenoplax*, *Paratrichodorus minor*, *Tylenchorhynchus claytoni*, *Hirschmanniella oryzae*, *Hoplolaimus magnistylus*, *Scutellonema bradys*, and undescribed species of *Criconema*, *Tylenchulus*, *Xiphinema*, and *Meloidogyne* (Wehunt *et al*., 1991). A second study from Colombia reported the presence of the nematode genera *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, *Trichodorus*, *Hemicycliophora*, and *Xiphinema* associated with roots of blackberry plants (Navarro and Múnera, 2000). A third study from Costa Rica reported the presence of plant-parasitic nematodes associated with several crops, but little information regarding the nematodes associated with blackberry was included (Esquivel and Peraza, 2010). For this reason, the main objective of this work was to determine the plant-parasitic nematodes associated with blackberry production plantations in Costa Rica.

MATERIALS AND METHODS

Description of study area

The research was conducted during 2005-2014, in nine blackberry plantations distributed in nine locations (one plantation per location): El Guarco in Cartago county, and León Cortés, San Marcos de Tarrazú, Santa María de Dota, and Pérez Zeledón in San José county (Table 1). A handheld global positional system device, GPSMap 60CSx (Garmin, Chicago, IL, USA) was used to record the locations.

Table 1. Geographic characteristics of blackberry-producing localities that were included in the study[x].

Province	County	Location	Latitude (N) and longitude (W)	Soil type[y] / life zone[z]	Height (masl)	Average temperature (°C)	Average precipitation (mm^3)
Cartago	El Guarco	La Luchita	09°44´43.80" 083°56´13.70"	Im-fo / Bmh-MB	1,929	6-12	4,000-8,000
San José	León Cortés	San Martín	09°43´43.20" 084°00´06.30"	Im-fo / Bmh-MB	1,864	6-12	4,000-8,000
		Cedral	09°43´04.20" 083°59´35.70"	Ut-fo / bmh-MB	2,096	6-12	4,000-8,000
	Tarrazú	Bajo Canet	09°42´01.20" 083°59´52.20"	Id-e / bh-MB	1,859	12-18	2,000-4,000
	Dota	La Trinidad	09º 39'58.70" 083º53'32.10"	Im-fo / bmh-MB	2,475	6-12	4,000-8,000
	Pérez Zeledón	División	09°30´27.60" 083°41´31.40"	Ut-e / bmh-MB	1,958	6-12	4,000-8,000
		Jardín	09°29´54.20" 083°41´54.90"	Ut-e / bmh-MB	2,130	18-24	4,000-8,000
		Buena Vista	09º 30'23.00" 083º39'27.38"	Ut-e / bmh-P	1,700	18-24	4,000-8,000
		Páramo	09º 25'04.77" 083º44'43.91"	Ut-e / bmh-P	1,059	18-24	4,000-8,000

[x]Source: Holdridge, 1982; Instituto Metereológico Nacional de Costa Rica (National Meteorological Institute of Costa Rica).
[y]Soil type: Im-fo: Inceptisols, young soil with B horizon, Tropept, Humitropept, strongly ondulated slope 30-60%. Ut-e: Ultisols, soil with argillic horizon, Humult, Tropohumult, wavy slope 60%. Ut-fo: Ultisols, soil with argillic horizon, Humult, Tropohumult, strongly wavy slope 30-60%. Id-e: Inceptisols, young soil with B horizon, Tropept, Dystropept.
[z]Life zones: bp-M: Montane pluvial forest, bp-P: Premontane rain forest, bh-MB: Humid low montane forest, bmh-P: Very wet premontane forest, bmh-MB: Very humid low montane forest

Soil and root sampling

Samples of soil and roots were collected all year round and in variable numbers (Table 1). Each soil sample consisted of 20 soil cores (1.5 cm × 20 cm) that were collected at equal intervals in a zig-zag pattern across the plantation. Soil cores were collected from around (25-cm–diam.) one plant and to a depth of 30 cm (Araya and Chaves, 1997). At each sampling point, rhizomes of blackberry plants were collected and visually examined for galls, lesions, and rotting symptoms caused by plant-parasitic nematodes. Final samples consisted of approximately 1 kg of soil and 50 g of roots. All samples were placed into polyethylene bags, properly labeled, and stored at 4ºC before analysis to minimize changes in nematode populations.

Nematode extraction and identification

Soil and roots samples were processed to extract nematodes using the centrifugation and sugar flotation method (Araya, 1995; Guzmán and Castaño, 1997). Roots were previously washed using tap water to obtain a homogenized mixture. All extractions were carried out in the Laboratory of Nematology at the Universidad Nacional in Heredia, Costa Rica. For identification purposes, nematodes were fixed in hot (70ºC) 4% formaldehyde, and subsequently infiltrated with glycerin using Seinhorst's modified slow method (Seinhorst, 1959; Seinhorst, 1962). Nematodes were quantified and identified to genus and species level (if possible) using a light microscope. The identification was carried out with help of taxonomic keys developed by Thorne (1961) and Mai *et al*. (1996). Images were digitized using a Nikon DS-Fil camera coupled to a Nikon Eclipse 80i (Nikon, Tokyo, Japan) and edited using Photoshop CS6®. The specimens were mounted in slide plates for their observation in an optical microscope Olympus BX50 (Olympus, Hamburg, Germany). Data were expressed as total number of nematodes in 100 g of soil + total number of nematodes in 10 g of roots (Khan, 2010). Mean numbers of nematode genera (mean frequency) and ranges were calculated per location.

RESULTS AND DISCUSSION

In total, 18 genera of plant-parasitic nematodes associated with blackberry (from 9 localities) were identified (Table 2). These comprised 15 genera of plant-parasitic nematodes (*Criconema*, *Criconemoides*, *Crossonema*, *Ditylenchus*, *Helicotylenchus*, *Hemicycliophora*, *Heterodera*, *Meloidogyne*, *Scutellonema*, *Pratylenchoides*, *Pratylenchus*, *Psilenchus*, *Trichodorus*, *Tylenchorhynchus*, and *Xiphinema*) and three genera of nematodes associated with plant roots, but their role as root feeders can be neglected (*Aphelenchoides*, *Aphelenchus*, and *Tylenchus*). Other studies reported around 21 species of plant-parasitic nematodes associated with blackberry in temperate and tropical climates (Wehunt *et al*., 1991; Navarro and Múnera, 2000). The most abundant genera of nematodes found in blackberry plantations of Costa Rica were *Helicotylenchus*, *Meloidogyne*, *Tylenchus*, *Trichodorus*, and *Aphelenchoides*. The genera *Helicotylenchus*, *Tylenchus*, *Meloidogyne* and *Criconema* were found in all the nine localities. The genera *Ditylenchus*, *Hemicycliophora*, *Psilenchus*, *Xiphinema*, *Pratylenchus*, *Tylenchorhynchus*, and some nematodes of the family Heteroderidae were identified in some of the localities. Four species are reported for the first time in association with blackberry plants in Costa Rica, these are *Crossonema civellae*, *Criconema neopacificum* and *Criconema graminicola* and *Criconemoides lizarbus* (Table 2).

In blackberry plantations of La Trinidad and San Martín, high densities of plant-parasitic nematodes were quantified, including 632 second-stage juveniles (J2) and 203 J2 (per 100 g of soil) of *Meloidogyne* sp. (root-knot nematode) respectively (Table 2). The root-knot nematode produced the typical root galling symptoms in most of the root samples from blackberry plants. However, the plants did not show any symptoms of damage, such as yellowing, decline, or poor development. This finding is important since there is potential for galled roots to be attacked by other soil pathogens, resulting in root-rotting decay. *Meloidogyne* has been reported previously as parasite of blackberry plants grown in other tropical sites (Navarro and Múnera, 2000) but also in other climatic regions (i.e., temperate) (Wehunt *et al*., 1991).

Nematodes from the genus *Pratylenchus* were observed in low numbers in 28% of soil samples and in 16% of root samples (Table 2). Due to low numbers of *Pratylenchus* in roots, it is likely that this nematode was not parasitizing blackberry plants but other weeds associated with the main crop. A finding that supports the hypothesis was the absence of the characteristic damage caused by *Pratylenchus*. Our finding contradicts other works that reported high populations of *Pratylenchus* in blackberry roots with negative effects on plant growth and productivity (Múnera and Navarro, 2002). The divergent results can be explained by the relative recent land-use change (i.e., since last decade) occurring in Costa Rica because many blackberry plantations were pasture-producing fields in the recent past. This change might translate into relative low numbers of nematodes parasitizing blackberry plants in the present,

Table 2. Range of nematodes and mean frequency (%) (in parenthesis) associated with blackberry plants by counties and localities. Nematode numbers are reported in total nematodes in 100 g of soil + total nematodes in 10 g of roots.

County	Locality	Number of samples[y]	Genera									
			Aphelenchus	*Aphelenchoides*	*Crossonema civellae*	*Criconema graminicola*	*Criconema neopacificum*	*Criconemoides lizarbus*	*Ditylenchus*	*Helicotylenchus*	*Hemicycliophora*	*Heterodera* sp.
El Guarco	La Luchita	11 (7S-1R)	3-6 (45.5)	1-27 (45.5)	3-112 (36.4)	1-8 (45.5)	-	-	1 (9.1)	4-448 (100.0)	3-10 (27.3)	-
León Cortés	San Martín	6 (5S-1R)	1-4 (60.0)	1 (80.0)	48 (40.0)	4-32 (100.0)	-	-	-	1-2 (80.0)	28 (40.0)	-
	Cedral	1 (1S)	-	8 (100.0)	-	24 (100.0)	40 (100.0)	-	-	32 (100.0)	1 (100.0)	24 (100.0)
Tarrazú	Bajo Canet	5 (5S)	-	24 (33.3)	6-100 (100.0)	6-46 (100.0)	-	29 (100.0)	-	8-304 (100.0)	-	8 (33.3)
Dota	La Trinidad	10 (7S-4R)	2-10 (33.3)	3-20 (33.3)	1-6 (44.4)	57 (11.1)	33 (100.0)	-	5 (11.1)	1-57 (66.7)	1 (11.1)	2-8 (22.2)
Pérez Zeledón	División	3 (2S-1R)	1-4 (66.7)	-	2-45 (100.0)	2-20 (66.7)	-	-	-	6-38 (100.0)	-	-
	Jardín	1 (1S)	6 (100.0)	-	42 (100.0)	16 (100.0)	-	35 (100.0)	-	204 (100.0)	8 (100.0)	6 (100.0)
	Buena Vista	7 (5S-2R)	1-4 (71.4)	1-31 (71.4)	-	9-20 (41.9)	-	-	-	1-22 (71.4)	-	-
	Páramo	4 (2S-2R)	9 (25.0)	-	2-15 (75.0)	1-4 (75.0)	-	-	-	15-174 (75.0)	1-3 (50.0)	-

Table 2 Continued.

County	Locality	Number of samples[y]	Genera								
			Meloidogyne	*Scutellonema*	*Prtatyenchoides*	*Pratylenchus*	*Psilenchus*	*Trichodrous*	*Tylenchus*	*Xiphinema*	Free-living[z]
El Guarco	La Luchita	3-10 (27.3)	1-40 (18.2)	-	-	-	-	-	2-176 (100.0)	-	7-256 (100.0)
León Cortés	San Martín	28 (40.0)	7-203 (100)	-	-	1-2 (80.0)	1-8 (40.0)	2-12 (60.0)	1-34 (100.0)	-	49-216 (100.0)
	Cedral	1 (100.0)	32 (100.0)	-	-	-	-	8 (100.0)	16 (100.0)	-	528 (100.0)
Tarrazú	Bajo Canet	-	45 (33.3)	-	-	2 (33.3)	-	2-8 (66.7)	10-80 (100.0)	2 (33.3)	65-236 (100.0)
Dota	La Trinidad	1 (11.1)	1-632 (77.8)	-	-	1-12 (44.4)	-	15-98 (22.2)	6-48 (88.9)	-	7-330 (100.0)
Pérez Zeledón	División	-	52-98 (66.7)	1 (33.3)	-	-	4 (33.3)	9-20 (66.7)	12-90 (100.0)	-	150-480 (100.0)
	Jardín	8 (100)	64 (100.0)	-	-	-	-	8 (100.0)	128 (100.0)	-	502 (100.0)
	Buena Vista	-	16-21 (42.9)	-	1 (28.6)	-	1-8 (28.6)	12-16 (42.9)	2-31 (100.0)	1-3 (57.1)	57-256 (100.0)
	Páramo	1-3 (50.0)	20-24 (50.0)	-	-	-	-	2 (25.0)	3-8 (75.0)	-	23-152 (100.0)

[y] * S (Soil) and Root (R).

[Z]Free-living nematodes: Rhabditids, Dorylaimids, and Mononchids.

however, we expect an increase in numbers of plant-parasitic nematodes, including *Pratylenchus* in the near future, due to a continuous cultivation of blackberry in time (i.e., no crop rotation) and space (i.e., monoculture).

Soil collected from La Luchita, Bajo Canet, Páramo, and Jardín, supported high densities of spiral nematodes (Table 2) (Figure 1A-B). *Helicotylenchus* are among the most ubiquitous plant-parasitic nematodes worldwide. These ectoparasites can be associated with other nematodes such as *Pratylenchus* and *Meloidogyne*, which may cause severe lesions in roots (Zunke, 1990; Davis and MacGuidwin, 2000; Lambert and Bekal, 2002; Perry and Moens, 2013). The observation of *Helicotylenchus* in soil suggests that blackberry is a host of this nematode, but identification of the species present in Costa Rica and quantification of damage, are aspects that have to be addressed in the future. Studies conducted in other regions reported that *H. paraplatyurus*, *H. platyurus*, and *H. pseudorobustus* were associated with blackberry (Wehunt *et al*., 1991) Individuals of the genus *Tylenchus* were also present in all localities (Table 2); however, this genus is considered a free-living nematode that feeds on algae, mosses, and lichens (Siddiqui, 2000), and its role as a plant-parasitic nematode can be neglected. The dagger nematode, *Xiphinema* sp. (Figure 1C-D), stubby-root nematode, *Trichodorus* sp. (Figure 1E-F) and *Hemicycliophora* sp. (Figure 1G-H), were detected in soil samples, but their presence was less frequent and population densities were variable (Table 2). These nematodes are reported to parasitize blackberry roots, causing injuries in tissue that are susceptible to the attack of other soil pathogens. Additionally, these nematodes may produce lesions on roots that can lead to rotting and decay of the root system. However, clear symptoms of damage and pathogenic potential of these nematodes have not been quantified in Costa Rica for blackberry. Species of *Xiphinema* (*X. americanum*), *Trichodorus*, *Hemicycliophora*, and *Criconema* have been previously reported in association with roots of blackberry (Wehunt *et al*., 1991; Navarro and Múnera, 2000). Nematodes of the genus *Xiphinema* are widely spread in Costa Rican crop fields (e.g., cocoa, coffee, rice, sugar cane, banana, onion, cotton, cas (*Psidium friendrischsthalianum*), chayote (*Sechium edule*), lettuce, bean, mango, orange, potato, pineapple, cabbage, beet and tomato) (Esquivel and Peraza, 2010). *Xiphinema* is an important genus because some species are virus vectors, with important implications in crop productivity (Lamberti and Roca, 1987; Weisher, 1993; Garrido, 1994; Taylor and Brown, 1994; Brown *et al*., 2004).

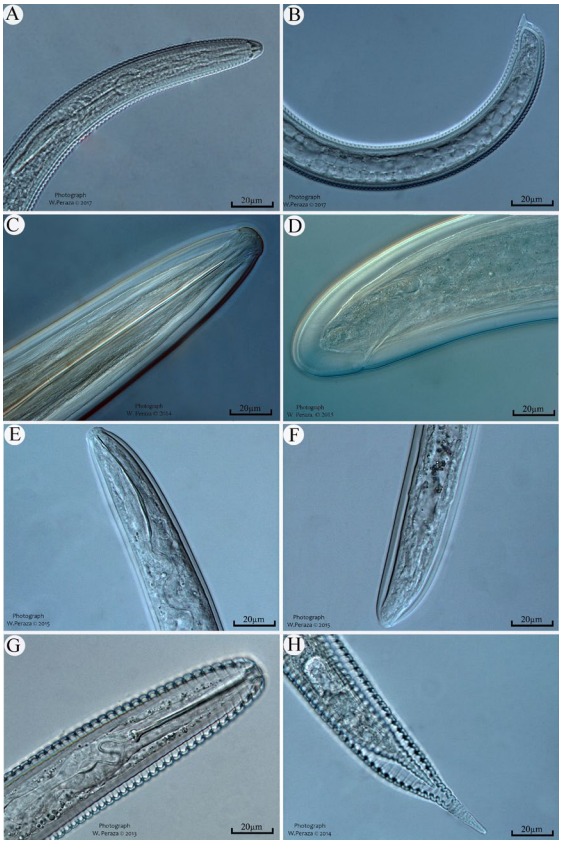

Fig. 1. Photomicrographs of anterior and posterior region of some plant-parasitic nematodes identified in this study. A) and B) *Helicotylenchus* sp. C) and D) *Xiphinema* sp. E) and F) *Trichodorus* sp. G) and H) *Hemicycliophora* sp.

The ecto-parasitic nematodes *Criconema graminicola* (Figure 2A-B), *Criconemoides lizarbus* (Figure 2C-D), *Criconema neopacificum* (Figure 2E-F), and *Crossonema civellae* (Figure 2G-H), were detected at low densities in soils from the survey sites (Table 2). These nematodes cause injury to roots making them susceptible to attack by other soil pathogens that invade the root and consequently weaken the plant (Lambert and Bekal, 2002). Importantly, this is the first report of the presence of *C. civellae*, *C. graminicola*, *C. neopacificum*, and *C. lizarbus* in blackberry plantations in Costa Rica. The presence of ring nematodes associated with blackberry plants is expected because many blackberry plantations were pasture-producing areas during the recent past. Ring nematodes are common parasites of pastures, therefore, their presence in blackberry plantations might constitute a soil legacy (Loof *et al*., 1997; Powers *et al*., 2010; Cordero *et al*., 2012; Zeng *et al*., 2015). Moreover, ring nematodes are present in a diverse variety of agroecosystems (e.g., areas, crops) in Costa Rica (Tarjan, 1971; López-Chaves, 1980; López-Chaves and Salazar-Figueroa, 1987; Arroyo *et al*., 2004; Wingching-

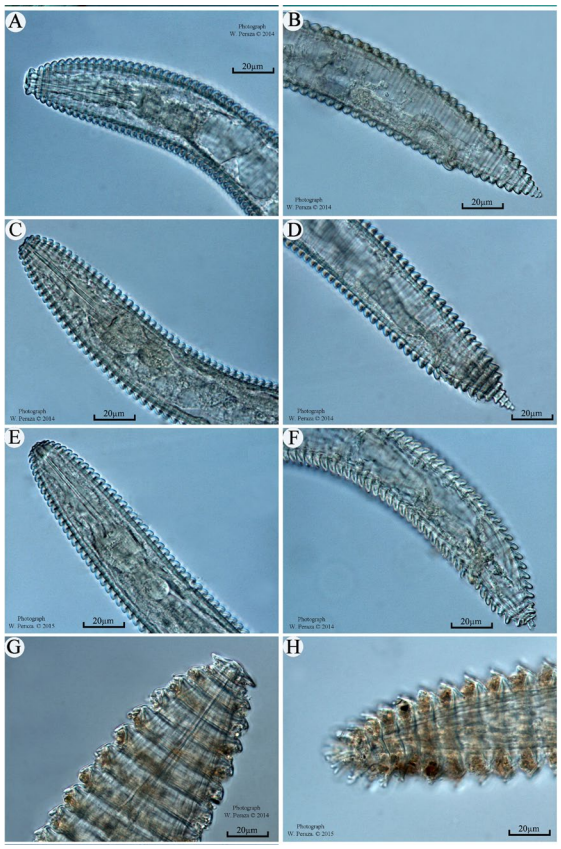

Fig. 2. Photomicrographs of anterior and posterior region of some ring nematodes identified in this study. A) and B) *Criconema graminicola*. C) and D) *Criconemoides lizarbus*. E) and F) *Criconema neopacificum*. G) and H) *Crossonema civellae*.

Jones *et al*., 2008; Guzmán-Hernández, *et al*., 2011; Pereza, 2014; Peraza-Padilla, 2018).

The occurrence of nematodes from the family Heteroderidae in soil collected from blackberry plantations can be explained by the presence of wild potatoes that coexist with blackberry plants, and which are hosts of nematodes of this family. However, this hypothesis has to be explored further. Abundant populations of free-living nematodes, including Rhabditids, Dorylaimids, and Mononchids, were also observed in association with blackberry plants (Table 2). These groups of nematodes play an important role in soil functioning because they contribute to nutrient recycling, regulation of population densities of other soil organisms (e.g., nematodes, fungi, and bacteria [among others]) (Neher, 2001). The nematodes *Ditylenchus* sp., *Scutellonema* sp., and *Pratylenchus* sp. were found in very low numbers in blackberry plantations in all localities.

The communities of plant-parasitic nematodes found in blackberry from other tropical countries such as Colombia (Navarro and Múnera 2000) were similar to those observed in Costa Rica, but they differed compared with non-tropical countries such as USA (Wehunt *et al*., 1991). In the latter, the species: *Pratylenchus vulnus*, *P. zeae*, *Criconemella axeste*, *C. curvata*, *C. denoudeni*, *C. ornata*, *C. shaerocephala*, *C. xenoplax*. *Paratrichodorus minor*, *Tylenchorhynchus claytoni*, *Hirschmanniella oryzae*, *Hoplolaimus magnistylus*, *Scutellonema bradys*, and *Tylenchulus* sp. were observed (Wehunt *et al*., 1991). Some of these genera were absent in Costa Rican blackberry plantations, for example, *Criconemella*, *Paratrichodorus*, *Tylenchorhynchus*, *Hirschmanniella*, *Hoplolaimus*, and *Tylenchulus*. In tropical ecosystems, the genera *Meloidogyne* and *Helicotylenchus* are commonly observed in roots of blackberry plants.

In conclusion, there is a wide variety of plant-parasitic nematodes associated with blackberry in Costa Rica. Given our detailed qualitative and quantitative study, we reported for the first time the presence of *C. civellae*, *C. neopacificum*, *C. graminicola*, and *C. lizarbus* in association with blackberry in Costa Rica.

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