Identification of plant parasitic nematodes in the Germplasm Bank of yellow passion fruit (*Passiflora edulis* f. *flavicarpa* Degener) in Colombia

Identificación de nematodos fitoparásitos en el Banco de Germoplasma de maracuyá (*Passiflora edulis* f. flavicarpa Degener) en Colombia

Rocío Alexandra Ortiz-Paz[1†], *Óscar Adrián Guzmán-Piedrahita*[2*], *y John A. Ocampo*[3‡]

[1]Agroforestal Engineer, Master student in Phytopathology, Universidad de Caldas, Manizales, Caldas, Colombia. [2]Agronomist Engineer, Ms. in Phytopathology. Auxiliar Professor, Departament of Agricultural Production, Faculty of Agricultural Sciences, Universidad de Caldas, Manizales, Caldas, Colombia. [3]Agronomist Engineer., Ph.D. Associated Professor, Universidad Nacional de Colombia - Palmira/International Center for Tropical Agriculture – CIAT, Colombia. *Corresponding author: oscar.guzman@ucaldas.edu.co; †roalorpaz@hotmail.com; ‡jaocampop@unal.edu.co

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Abstract

Plant parasitic nematodes are one of the major constraints in tropical fruit causing great economic losses by reducing yields. In Colombia there is not information dealing with the production systems about these parasites affecting passion fruit cultivation so, it is necessary to generate information for management strategies. The aim of this study was to identify and quantify plant parasitic nematodes present in the National yellow passion fruit Collection consisting of 28 accessions from different origin and established in the farm Luker in Palestina (Caldas), Colombia. Sample collection was carried out in the root area of each plant at a depth of 60 cm in each accession. Three samples of 100 g of functional root system and 100 g of soil were taken. The extraction of root and soil nematodes was based on the flotation principle of nematodes in sugar. For data an univariate analysis with the estimated average, the coefficient of variation, analysis of variance and Tukey test at 5%, to establish the differences among accessions was performed. Results showed seven kinds of soil and root phytonematodes: *Helicotylenchus*, *Rotylenchulus*, *Radopholus*, *Meloidogyne*, *Tylenchus*, *Aphelenchoides* and *Trichodorus*. The species most frequently found in root and soil of accessions were *Helicotylenchus dihystera*, *Rotylenchulus reniformis* and *Radopholus similis* with 100, 75 and 61%, respectively. Results showed 11, 8 y 16 accessions without parasitism of the genera *Radopholus*, *Rotylenchulus* and *Meloidogyne*, respectively. Among these, accession AntFla03 and CauFla01 were outstanding due to their agronomic characteristics which constitute a gene pool for breeding programs in search for phytoparasitic nematode resistance or tolerance that involve hybridization or grafting.

Key words: Colombia, *Helicotylenchus*, maracuyá, *Passiflora edulis*, phytonematodes, plant nematodes, *Radopholus similis*, *Rotylenchulus*.

Resumen

Los nematodos fitoparásitos son una de las mayores limitantes en la fruticultura tropical causando grandes pérdidas económicas por la reducción de los rendimientos. En Colombia no existe información respecto a estos parásitos que afectan el cultivo del maracuyá y es necesario generarla para crear estrategias de manejo. El objetivo del estudio fue identificar y cuantificar los nematodos fitoparásitos presentes en plantas de maracuyá de la Colección Nacional, conformada por 28 accesiones de diferentes

procedencias establecida en la Granja Luker en Palestina, Caldas (Colombia), a 1058 m.s.n.m., 5° 4' 13.2" N y -75° 41' 7.7" O, 23 °C, 2250 mm/ao y 75% de HR. La recolección de las muestras se realizó en la zona de plateo de cada planta hasta 60 cm de profundidad. En cada accesión se tomaron tres muestras de 100 g de raíces funcionales y 100 g de suelo. La extracción de nematodos de raíces y suelo se realizó con base en el principio de flotación en azúcar. Para los datos se desarrolló un análisis univariado con la estimación del promedio, el coeficiente de variación, el análisis de varianza y prueba de Tukey al 5%, para establecer las diferencias entre accesiones. Se recuperaron nematodos de siete géneros, *Helicotylenchus*, *Rotylenchulus*, *Radopholus*, *Meloidogyne*, *Tylenchus*, *Aphelenchoides* y *Trichodorus*. Las especies con mayor frecuencia en las accesiones, tanto en raíces como en suelo, fueron *Helicotylenchus dihystera*, *Rotylenchulus reniformis* y *Radopholus similis* con 100, 75 y 61%, respectivamente. Se encontraron 11, 8 y 16 accesiones de maracuyá sin parasitismo de los géneros *Radopholus*, *Rotylenchulus* y *Meloidogyne*, respectivamente. Dentro de éstas, sobresalen las accesiones AntFla03 y CauFla01 por sus características agronómicas, las cuales constituyen un reservorio genético para programas de fitomejoramiento en la búsqueda de resistencia o tolerancia a nematodos fitoparásitos que involucren hibridación o injertación.

Palabras clave: Colombia, fitonematodos, *Helicotylenchus*, maracuyá, nematodos de las plantas, *Passiflora edulis*, *Radopholus similis*, *Rotylenchulus*.

Introduction

Passion fruit (*Passiflora edulis* f. *flavicarpa* Degener) is, economically, the main species of the genus Passiflora L. it is distributed in tropical zones from the sea level till 1350 MASL. It is a species originated in the amazon region and described in the isle of Hawaii (USA) in 1932 by Degener, from where it was distributed to other tropical countries in the world (Degener, 1932; Morton, 1967; Ulmer, 2004; Ocampo and Urrea, 2012). In Colombia, it was introduced early 1960, in the department of Valle del Cauca and, nowadays it is the third world producer, with around 6000 ha cultivated, after Brazil and Ecuador (Jaramillo *et al.*, 2009). In the country, passion fruit production is close to 92,000 t (Agronet, 2012) and is concentrated in the departments of Huila with 1234 ha and 18,838 t, Meta with 759 ha and 15,452 t and Valle del Cauca with 641 ha and 12,012 t. 75% of the national production is exported to European countries as concentrated juice and the rest is commercialized as fresh fruit in local markets (Isaacs, 2009). Passion fruit has conquered international markets with its aroma, its organoleptic characteristics and medicinal properties (Yockteng *et al.,* 2011). The plant grows on loam to sandy-loam soils with a minimum depth of 60 cm, rich in organic matter, well drained and pH between 5.5 and 7.5 (García, 2002; Lima and Cunha, 2004). It prefers locations with rainfall between 800 to 1500 mm/year, temperature from 20 to 25 °C and relative humidity lower than 80% (Fischer *et al.,* 2009; Ocampo *et al.,* 2012).

Passion fruit crop is affected by fungi, bacteria, virus and phytoparasite nematodes, reducing its production up to 50% and causing big economic losses for the producers. Increment in pest incidence and severity like the ovary or floral button fly, *Dasiops gracilis*, *D. enedulis* and *D. yepezi*, and diseases like vascular wilt by *Fusarium oxysporum* f. sp. *passiflorae*, Schlecht, bacterial blight, *Xanthomonas campestris* pv. *passiflorae* Pereira, scab, *Cladosporium cladosporioides* Fresen, Soybean mosaic virus SMV and phytoparasite nematodes like *Meloidogyne* spp., *Rotylenchulus* spp. and *Helicotylenchus* spp., cause phytosanitary pressure (Lozano, 2008; Castaño, 2009; Hernández et al., 2011), increase crop damaging and the demand for chemical treatments against human health and environment (Guerrero- López and Hoyos-Carvajal, 2011; Villegas *et al.,* 2012). Nematodes on this crop have been poorly studied and, the phytosanitary diagnose by producers consist on visual inspection that is confused with nutrient element deficiencies.

Nematodes are filiforms of microscopic size (300 to 1000 µm length x 15 to 35 µm wide) that inhabit soil (Agrios, 2005; Luc et al., 2005). Phytoparasite nematodes cause internal and external damage on plant roots when feeding by using their stylet and, some of

them can cause galls or nodes like the ones from the *Meloidogyne* spp. genus or being associated with soil fungi like *Fusarium* spp. (Mai *et al.*, 1996; Siddiqi, 2000; Fischer *et al.*, 2010).

In a study performed in the departments of Valle del Cauca, Cauca and Caldas, Sanchez et al. (1993) registered nine phytoparasite nematodes genus that affect passion fruit crop, among them *Rotylenchulus reniformis* Lindford and Oliveira presented the highest frequency on soil (72%) and in roots (25%) when compared to *Helicotylenchus* sp., *Tylenchorhynchus* sp. and *Meloidogyne* sp. that did not exceed 19%. On a similar study, Suárez *et al.* (1994) observed that *R. reniformes* is the nematode with the highest incidence in passion fruit crops in Central Venezuela (Aragua, Barinas, Carabobo and Miranda), it causes reduction on root emission and yellow leaves.

In laboratory conditions, Suarez et al. (2002) found that this nematode reduces the aerial and root weight of passion fruit plants and reproduces 2.5 times more in relation to the initial inoculum. Other studies in passion fruit and purple passion fruit (*P. edulis* Sims) showed that *Meloidogyne incognita* (Kofoid and White) Chitwood, *M. javanica* (Treub) Chitwood and *Helicotylenchus dihysteroides* Siddiqi as nematodes that destroy the root system (Suárez *et al.,* 1994; Sikora and Fernández, 2005; Lozano, 2008). Among the phytoparasite nematodes, the ones that form galls belonging to the Meloidogyne genus are considered the most economically important ones because of the damage that cause on vegetables, fruits, ornamentals and weeds (Agrios, 2005). In this genus there are more than 89 nominal species, however, *M. incognita*, *M. javanica*, *M. arenaria* (Neal) Chitwood and *M. hapla* (Chitwood) cause large economic losses on agricultural areas of the world (Rodríguez-Kábana and King, 1987; Cia and Salgado, 2005; Sikora and Fernández, 2005; Fischer *et al.*, 2010).

In Colombia, the studies related with phytoparasite nematodes on *Passiflora* L. cultivated species and especially in passion fruit, are scarce. Due to the importance of this crop in the country, to the effect of these nematodes on the root system and aerial part of the plant, and similarly, to explore the genetic component as a management strategy, the objective of this work was to identify and quantify phytoparasite nematodes present on the Passion fruit National Collection located in the Granja Luker (Palestina, Caldas), under the research project Exploitation of passion fruit, purple passion fruit and granadilla diversity to improve and diversify the production systems in Colombia Ministry of Agriculture and Rural Development–MADR, as a contribution to the knowledge on sanitary problems of this crop and to the fruit culture in general.

Materials and methods

Research was performed at the Luker farm, located in Palestina, Caldas (Colombia), at 1058 MASL, 5° 4' 13.2" N and -75° 41' 7.7" W. average temperature of 23 °C, annual precipitation of 2250 mm, relative humidity of 75% and daily solar brightness of 6 h. Soils are high in organic matter, sandy-loam and pH 6.8 (Aristizábal, 2002).

Passion fruit germplasm bank, established at the Luker farm in October 2009, is composed by 28 accessions from different origins (Table 1). The spatial arrangement of the collection is randomized blocks with two replicates and an experimental unit of 5 plants with a simple trellis system sowed at 3 x 3 m.

For the experiment, samples were collected in the clean area close to the stem of four plants of each of the 28 accessions. Samples were collected from rectangular holes 40 cm side x 60 cm depth, three samples of 100 g with functional roots and soil were collected in transparent plastic bags, properly labelled with the accession code, before they were sent for processing and analysis to the Phytopathology lab of the Department of Agricultural Production of the Universidad de Caldas.

Nematode extraction from roots and soil was performed by following the flotation principle of nematodes on sugar (Jenkins, 1964; Araya *et al.*, 1995). For that, roots were washed with tap water, weighted and cut in 30 cm length pieces before blending them with 500 ml of water at high speed for 30s on an Osterizer blender. Liquefied solution was passed through a 250 µm sieve placed at the same time on a 25 µm sieve. Sample was

Table 1. List of Passion fruit (*Passiflora edulis* f. *flavicarpa*) accesiones of the Germplasm Bank in Colombia.

Accesion (no)	Code	Department	Town
1	AntFla01	Antioquía	Sopetrán
2	AntFla02	Antioquía	Santa Barbara
3	AtlFla01	Atlántico	Barranquilla
4	CalFla02	Caldas	Neira
5	CalFla03	Caldas	Viterbo
6	CauFla01	Cauca	El Patia
7	CauFla02	Cauca	El Patia
8	CauFla03	Cauca	El Patia
9	CauFla05	Cauca	Guachene
10	CunFla02	Cundinamarca	Caparrapi
11	HuiFla02	Huila	El Agrado
12	HuiFla03	Huila	Garzón
13	HuiFla06	Huila	Rivera
14	TolFla01	Tolima	El Guamo
15	TolFla02	Tolima	El Guamo
16	TolFla04	Tolima	Flandes

washed by water pressure to cause nematode separation, and the sample remaining on the 25 µm sieve was placed on 30 ml tubes that were centrifuged at 3800 rpm for 5 min. Next, supernatant was discarded and a 50% sucrose solution was added before repeating the centrifugation. Floating nematodes on the sucrose solution were placed on the 25 µm sieve to wash the sucrose with water at low pressure and, finally to take 20 ml of water with nematodes on a Petri dish. Soil nematode extraction was done in a similar way but omitting the blending step.

Obtained samples were transferred to Petri dishes containing 6 quadrants of 6 x 6 cm and it was extrapolated to a 100 g sample of roots or soil. Three quadrants were selected randomly and the number of nematodes was quantified by microstereoscope in each one of them.

To identify plant nematodes 20 nematodes from each Petri dish were taken and with the help of a dissection needle were mounted on a microscope slide with a drop of water for their observation on a light compound microscope (Nikon, 40x). Identification of genus and species was done with the Siddiqi´s taxonomical keys (2000), figures published by Mai *et al.* (1996), C.I.H. plant nematodes descriptors (1972-1977) and, according to the experience of the second author of this publication.

For data univariate analysis was performed estimating the average, coefficient of variation, analysis of variance and Tukey's test at 5% in order to establish differences between accessions. To perform statistics it was taken into account a frequency of 100% when a nematode species was found in all the four samples. Analysis were performed with the statistical software SAS v. 8.1 (Statistical Analysis Software, 2000).

Results and discussion

Identification of plant parasite nematodes

On the 28 accessions of passion fruit evaluated there were identify seven plant nematodes genera: *Rotylenchulus* spp., *Helicotylenchus* spp., *Radopholus* spp., *Meloidogyne* spp., *Tylenchus* spp., *Aphelenchoides* spp. and *Trichodorus* spp. These genera belong mainly to the class Secernentea, order Tylenchida, families Hoplolaimidae, Pratylenchidae, Meloidogynae, Tylenchidae and Aphelenchidae, respectively (Mai *et al.*, 1996; Siddiqi, 2000; Perry *et al.*, 2009). Genus *Trichodorus* spp. belongs to the class Adenophorea, order Dorylaimida, family Trichodoridae (Mai *et al.*, 1996).

Populations of the plant parasite nematodes *Rotylenchulus reniformis* and *Helicotylenchus dihystera*

In these genera, the largest number of individuals was found in 100 g of root samples, with values ranging from 1 in the Bavaria accession till 181 in the CunFla02 accession for *Rotylenchulus* and, from 77 in TolFla04 till 337 in CalFla03, with a coefficient of variation (CV) of 8.3% (Table 2 and Table 3). Accessions with the largest *Rotylenchulus* spp. in 100 g of roots were found in the department of Cauca in the accessions CaulFla01, CaulFla02, CaulFla03 and CaulFla05, Antioquia in AntFla01 and AntFla03, Huila in HuiFla02, HuiFla03 and HuiFla06; Cundinamarca in CunFla02; and Caldas in CalFla02 and

Table 2. Coefficients of determination and variation in the plant parasite nematodes in plant roots and soils cultivated with passion fruit.

Genus	Coef. of determination (R^2)		Coef. of variation (CV)		Pr > F
	Root	Soil	Root	Soil	Root or Soil
Helicotylenchus	0.7760	0.7622	17.6608	22.7827	<0.0001
Rotylenchulus	0.9480	0.8091	35.8620	47.9835	<0.0001
Meloidogyne	0.9898	0.9363	14.7043	39.4166	<0.0001
Radopholus	0.9063	0.8302	34.3639	53.7271	<0.0001
Aphelenchoides	0.9344	0.9184	19.7203	27.9826	<0.0001
Trichodorus	0.9498	0.8896	149.0144	228.7183	<0.0001

CalFla03. For the genus *Helicotylenchus* spp. all the accessions showed populations ranging from 77 to 337/100 g of roots in the TolFla04 and CalFla03, respectively (Table 3, Figure 1).

In the soil samples, total populations for both nematode genera were lower to the ones found for roots (Table 3), with an average of 252, ranging from 103 to 400 nematodes/100g and a CV of 14.6%. Minimum values of the populations were shown on the TolFla01, TolFla02, TolFla04 and TolFla07 accessions from Tolima, and in all the evaluated accessions from Valle del Cauca (Table 3).

Helicotylenchus spp., with 100% of incidence, average of 214 nematodes/100 g of roots and 98 nematodes/100 g of soil was a the most frequently observed genus in the samples (Table 3). *Rotylenchulus* spp. with 75% was the second most abundant (Table 3, Figure 1). Sánchez *et al.* (1993) found in commercial passion fruit crops in the departments of Valle del Cauca, Cauca and Caldas that *R. reniformis* was the most frequent species with 72% and 25% on soil and roots, respectively, followed by *Helicotylenchus* spp. with presence of 19% in soil and 0.6% in roots.

It should be mentioned that *Rotylenchulus* spp. was not found in the accessions TolFla02, TolFla04, TolFla07, ValFla01; ValFla03; ValFla04, ValFla09; ValFla10 and Bavaria, allowing them to be suggested as possible genetic pools, with potential resistance to the identified nematodes on this study.

The low coefficients of variation (CV) found (< 35%) showed a low data dispersion for the nematode populations in each accession and genus representation in each of them (Table 3). Coefficients of determination (R^2) obtained ranging from 0.70 and 0.99, suggesting a homogeneous distribution of the values on each accession in relation to the mean (n.p.), which is in addition to the interaction between the presence of different nematode genus on each accession (Table 2).

Populations of *Meloidogyne* spp. and *Radopholus similis*

Radopholus similis had a frequency of 61% with values between 73 and 190 individuals/100 g of roots for the accessions CauFla03 and ValFla08, respectively (Table 3). *Meloidogyne* spp. genus had frequencies between 43 and 39% in soil and roots, with values between 18 and 180 individuals per sample (soil and roots) in the accession AntFla03 (Table 3). Similarly, *Meloidogyne* spp. was not registered for the accessions AtlFla01, CalFla02, CauFla01, CauFla03, CauFla05, CunFla02, HuiFla02, HuiFla03, HuiFla06, TolFla01, TolFla02, VaLFla04, VaLFla05, VaLFla06, VaLFla07 and VaLFla08 (Table 3).

El-Borai and Duncan (2005) found that reniform nematodes *R. reniformis* and the ones of the root knot, *M. incognita*, *M. javanica* and *Meloidogyne* spp. affect longevity of passion fruit plants and limit the fruit production with large economical damage. Similarly, *R. reniformis* was detected on 84% of samples collected in Fiji islands (Oceania) with densities of 36,000 nematodes on 200 cm^3 of soil. In Belize and Brazil, *R. reniformis* has been

Table 3. Average number (population) of phytopathogen nematodes per 100 g of roots and soil in 28 accessions of the Germplasm Bank of Passion Fruit in Colombia.

Accessions	*Rotylenchulus*		*Helicotylenchus*		*Radopholus*		*Meloidogyne*		*Aphelenchoides*		*Tylenchus*		*Trichodorus*	
	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil	Root	Soil
AntFla01	61 cd*	30 bdc	221 ebdacf	137 bac	119 bac	45 ebdac	170 ba	28 ba	38 fe	29 gf	163 bac	48 ba	0 b	0 b
AntFla03	56 ed	20 bdc	226 ebdacf	155 a	141 bac	90 ba	180 a	18 b	38 fe	41 egf	156 bac	60 a	0 b	0 b
AtlaFla01	89 cbd	34 bdc	267 bac	123 ebdac	163 ba	56 bdac	0 d	0 c	0 f	0 g	177 ba	41 bdac	0 b	0 b
CalFla02	70 cbd	19 dc	257 bdac	130 bdac	0 d	0 e	0 d	0 c	0 f	0 g	170 ba	40 ebdac	0 b	0 b
CalFla03	46 fed	30 bdc	337 a	122 ebdac	141 bac	52 ebdac	166 ba	21 b	0 f	0 g	177 ba	45 bac	0 b	0 b
CauFla01	83 cbd	23 bac	233 ebdacf	148 ba	80 bddc	31 edc	0 d	0 c	0 f	0 g	177 ba	41 bdac	0 b	0 b
CauFla02	105 cb	26 bdc	267 bac	121 ebdac	0 d	0 e	170 ba	19b	63 de	43 egf	170 ba	37 ebdac	0 b	0 b
CauFla03	75 cbd	53 bac	242 ebdacf	123 ebdac	73 dc	34 edc	0 d	0 c	78 de	48 edgf	148 bac	59 a	0 b	0 b
CauFla05	73 cbd	26 bdc	225 ebdacf	114 ebdac	141 bac	19 ed	0 d	0 c	0 f	0 g	155 bac	37 ebdac	0 b	0 b
CunFla02	181 a	27 bdc	222 ebdacf	77 ebdcf	0 d	0 e	0 d	0 c	0 f	0 g	181 ba	45 bac	0 b	0 b
HuiFla02	108 b	27 bdc	119 gf	38 f	0 d	0 e	0 d	0 c	0 f	0 g	189 ba	37 ebdac	0 b	0 b
HuiFla03	89 cbd	18 dc	285 ba	56 ef	0 d	0 e	0 d	0 c	144 ba	103 bac	129 bac	33 ebdac	0 b	0 b
HuiFla06	8 fg	67 ba	137 edgf	53 ef	0 d	0 e	0 d	0 c	129 bac	104 bac	119 bac	44 bac	0 b	0 b
TolFla01	3 fg	52 bac	238 ebdacf	122 ebdac	0 d	0 e	0 d	0 c	106 bdac	86 ebdac	155 bac	37 ebdac	0 b	0 b
TolFla02	0 g	0 d	260 bac	132 bac	0 d	0 e	0 d	0 c	119 bdac	56 edcf	192 a	32 ebdac	0 b	0 b
TolFla04	0 g	0 d	77 g	92 ebdacf	113 bac	49 ebdac	144 bc	37 a	126 bdac	119 ba	136 bac	34 ebdac	0 b	0 b
TolFla07	0 g	0 d	127 egf	74 edcf	133 bac	30 edc	130 c	30 ba	137 bac	92 ebdac	147 bac	30 ebdc	0 b	0 b
VaLFla01	0 g	0 d	118 gf	73 edcf	112 bac	41 ebdc	153 bac	22 b	156 ba	56 edcf	132 bac	33 ebdac	0 b	0 b
VaLFla03	0 g	0 d	238 ebdacf	89 ebdacf	104 bc	52 ebdac	146 bc	32 ba	126 bdac	78 ebdacf	148 bac	18 edc	0 b	0 b
VaLFla04	0 g	0 d	223 ebdacf	81 ebdcf	100 bc	78 bac	0 d	0 c	111 bdac	104 bac	136 bac	15 ed	0 b	0 b
VaLFla05	3 fg	41 bdac	160 edgcf	56 ef	108 bac	100 a	0 d	0 c	122 bdac	112 ba	134 bac	29 ebdc	0 b	0 b
VaLFla06	3 fg	62 bac	213 ebdcf	59 edf	123 bac	45 ebdac	0 d	0 c	104 bdac	74 ebdcf	130 bac	27 ebdc	0 b	0 b
VaLFla07	13 feg	48 bac	225 ebdacf	92 ebdacf	137 bac	48 ebdac	0 d	0 c	162 a	78 ebdacf	163 bac	26 ebdc	0 b	0 b
VaLFla08	4 fg	34 bdc	224 ebdacf	99 ebdacf	190 a	70 bdac	0 d	0 c	140 bac	81 ebdacf	137 bac	32 ebdac	0 b	0 b
VaLFla09	0 g	0 d	197 ebdacf	52 ef	126 bac	58 bdac	155 bac	0 c	0 f	119 ba	136 bac	12 e	59 a	177 a
VaLFla10	0 fg	82 a	237 ebdacf	130 bdac	0 d	0 e	152 bac	37 a	138 bac	0 g	147 bac	30 ebdc	0 b	0 b
Bavaria	0 g	67 ba	222 ebdacf	87 ebdacf	0 d	0 e	151 bac	32 ba	96 bdec	130 a	114 bc	30 ebdc	0 b	0 b
Comercial	0 g	63 bac	208 ebdacf	114 ebdac	0 d	0 e	129 c	22 b	153 ba	99 bdac	92 c	19 edc	0 b	0

*Values on the same column followed by the same letters are not statistically significant according to Tukey's test ($P < 0.05$).

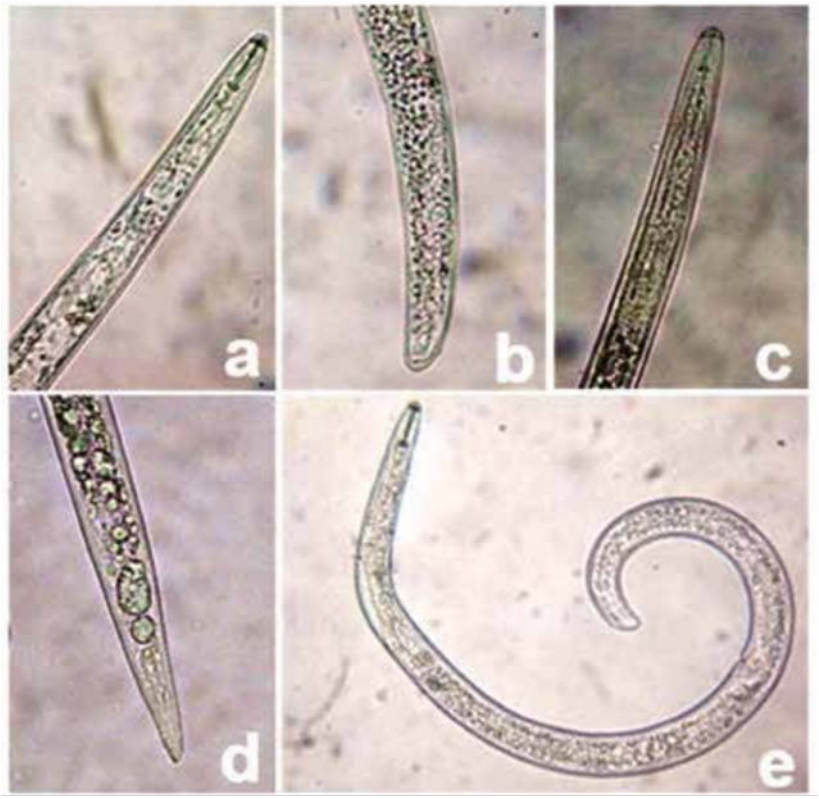

Figure 1. Main genus of plant parasite nematodes found on passion fruit accessions. *Rotylenchulus* sp., anterior region at40X (a), posterior region at 40X (b). *Radopholus similis*, anterior region (c) posterior region (d) of a female at40X. *Helicotylenchus dihystera*, full body of a female at 10X (e)

found to be associated with passion fruit root system (Bridge *et al.,* 1996; Sharma *et al.*, 2000).

Sikora and Fernández (2005) observed that the knot nematodes *M. incognita*, *M. javanica*, *R. reniformis* and *H. dihysteroides*, caused root deformations, weaken plants, produce chlorosis and descendant death. Wounds in the root system favor necrosis by penetration of other natural soil pathogens.

R. similis presence (Figure 1) is the first registry of a borer nematode in passion fruit plants in Colombia, with a frequency of 61% in the 28 evaluated accessions. This species is mainly feed on roots and corms of banana and plantain and, affects growth and development of these crops causing production losses between 20 and 80% (Guzmán-Piedrahita, 2011). Milne and Keetch (1976) considered that passion fruit is a rotation crop in Southafrica used for control of *R. similis*, that does not infect *P. edulis* f. *edulis* (purple passion fruit) and *P. edulis* f. *flavicarpa* (passion fruit).

Plant parasite nematodes *Tylenchus*, *Aphelenchoides* and *Trichodorus* were found in frequencies of 100%, 71% and 4%, respectively. The last one was only seen in the accession CalFla03 with 60 individuals in root samples, which is contrasting with the results of Sánchez *et al.* (1993), which observed lower percentages of *Pratylenchus* spp., *Tylenchorhynchus* spp., *Aphelenchus* spp., *Criconemella* spp., *Hoplotylus* spp., and *Xiphinema* spp. on passion fruit crops from the departments of Valle del Cauca y Caldas. Differences could be due mainly to different soil uses, to the hosts present before crop establishment and to environmental conditions.

Differences between the nematode populations in the Passion fruit Germplasm Bank compared to other studies are explained by the genetic variability present in the bank which is composed by accessions of different geographical origins of the country. Variability that is represented by accessions with more tolerance or susceptibility to plant parasite nematodes, that can be considered as genetic pool for assisted selection of elite genotypes and, that contribute to the solution of problems with these microorganisms and to mitigate economic losses for producers. The absence (0) of plant parasite nematodes on the

roots of some accessions suggests an apparent tolerance to these organisms and can be considered as elite genotypes.

This genetic resistance as strategy to control diseases can be evaluated in nursery conditions to evaluate the advantages of these materials.

Conclusions

- Results determined the presence of seven genus of plant parasitic nematodes in the 28 evaluated accessions of passion fruit, both in root and soil samples. They are nematodes associated mainly with the genera *Helicotylenchus* spp. and *Rotylenchulus* spp., with an incidence between 100% and 75%, respectively.
- Presence and number of plant parasitic nematodes on the studied germplasm, allow concluding that there is a genetic variability for susceptibility and resistance to these organisms on the passion fruit accessions that were evaluated. Similarly, the methodology used in this study is suggested for further studies on identification and quantification of nematodes on passion fruit crops.
- The study identified the accessions AntFla03, CalFla03, CauFla01, CauFla02 and HuiFla06 with tolerance to one or two of the genera *Helicotylenchus* spp., *Rotylenchulus* spp. and *Meloidogyne* spp. reported in this research. The apparent nematode tolerance reported in some accessions is fundamental for breeding programs in passion fruit that search for cultivars with higher tolerance to phytosanitary problems that allow a better crop development and reduction on chemical treatment use for their control.

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