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# PLANT-PARASITIC NEMATODES IN THE WINE-GROWING REGION OF NORTHERN VALLE DEL CAUCA, COLOMBIA: PRESENCE AND DISTRIBUTION IN TWO PRODUCTION AREAS

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## ABSTRACT

Grapevine (*Vitis vinifera* L.) is a crop of growing economic importance in northern Valle del Cauca, Colombia, particularly in the municipalities of La Unión and Toro. However, information regarding plant-parasitic nematodes associated with local vineyards is limited. This study aimed to characterize the diversity, population structure, and phytosanitary risk of plant-parasitic nematodes in two grape-producing areas through morphological identification and ecological parameter analysis. Soil (100 g) and root (10 g) samples were collected from six vineyard plots located between 900 and 1,100 m a.s.l. Nematodes were extracted using modified sieving, decanting, and maceration techniques and identified based on diagnostic morphological traits. Absolute and relative frequency, density, and prominence values were calculated to describe community structure. Two plant-parasitic genera were consistently detected: *Helicotylenchus* and *Pratylenchus*, together with free-living nematodes. *Helicotylenchus* exhibited the highest absolute frequency (100%) in both soil and root samples and the greatest relative density in soil (47.6%), confirming its dominance and broad distribution in the study area. *Pratylenchus* showed lower but significant frequencies (26.7% in soil and 29.4% in roots) and relevant densities in root tissues, consistent with its migratory endoparasitic behaviour and potential to induce root lesions. Prominence values reinforced the ecological predominance of *Helicotylenchus*, while *Pratylenchus* represented an important secondary component. Free-living nematodes reached relative frequencies above 25%, suggesting a partially balanced soil food web despite the dominance of plant-parasitic taxa. The coexistence of these genera indicates moderate biological pressure on grapevine root systems, potentially affecting plant vigour and productivity under stress conditions. These findings provide baseline nematological information for vineyards in northern Valle del Cauca and support the development of integrated management strategies to ensure sustainable grape production in the region.

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**KEYWORDS:** *Vitis Vinifera*; *Helicotylenchus*; *Pratylenchus*; Phytosanitary Risk; Soil Nematode Community.

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## 1. INTRODUCTION

Grapevine farming (*Vitis vinifera* L.) is one of the most valuable farming operations in the world in terms of economic importance as well as its historical and cultural importance. The world produces over 75 million tons of grapes every year, and the top countries of production are China, Italy, the United States, and Spain (FAO, 2022). *V. vinifera* was native to the Caucasus region and some parts of Europe and has gone through a long domestication and diversification process, which has enabled it to adapt to many soil and climatic conditions (Keller, 2010). Nowadays, the specified species covers over 95% of the global vineyard, which further establishes it as the primary crop fruit in the wine sector as well as the fresh consumption market (OIV, 2023).

Grapevine cultivation was introduced in the 16th century when the Spaniards colonized Mexico and Peru, and then afterwards, spread to Chile, Argentina and the United States, where it enjoyed conducive conditions to worldwide commercialization (Martinez de Toda, 2011). In Colombia, even though the production of grapes does not match that of the other countries producing wine, this crop has acquired more and more economic significance in recent decades, which is determined by the national market and by the diversification of production systems. It is estimated that it produces about 15,000 tons per year, most of which are located in the departments of Boyaca and Valle del Cauca, and the cultivated area is approximately 2,000 hectares (DANE, 2022). Specifically, La Union and Toro municipalities in the north of Valle del Cauca are now strategic locations to have table grape (*V. vinifera*) production, which is an important part of the agricultural economy in the region (Ministry of Agriculture and Rural Development, 2021).

Although grape production is of productive significance, there are numerous phytosanitary limitations of grape production that influence its productivity and longevity. The major micro-organisms linked with low productivity are fungus-like *Botrytis cinerea* and *Plasmopara viticola*, bacteria like *Xylella fastidiosa* and most especially the plant-parasitic nematodes that have a direct impact on the root system by disrupting water and nutrient uptake and predisposing plants to other pathogens present in soil (Moens et al., 2009; Nicol et al., 2011). It has been reported in numerous studies that genera like *Pratylenchus*, *Meloidogyne* and *Xiphinema* are known to result in considerable economic losses within vineyards where reduction of yields is between 10 and 40 per cent, depending on environmental factors,

agronomic control and levels of population (Zasada et al., 2010). Specifically, grapevine-carrying viruses are highly dangerous vectors that are transmitted by species of the genus *Xiphinema*, thus affecting the quality of production and the life of vineyards (Perez et al., 2018).

Plant-parasitic nematodes in Valle del Cauca have received limited and, largely, exploratory studies. Preliminary studies, including those by Baeza (1970), found genera including *Meloidogyne*, *Helicotylenchus*, *Xiphinema* and *Pratylenchus* to be associated with different crops, including grapevine. These studies were, however, restricted to general presence records and not the structure, population dynamics and the phytosanitary risk posed by these organisms in certain production systems like vineyards. The more recent research in the area has centred on the productive characterization as well as the phytosanitary management practices in the grape cultivation. Cano Benitez and Cano Benitez (2012) and Cano Benitez et al. (2020) examined the production systems of *Vitis labrusca* in Valle del Cauca and found that the systems had sanitary problems and control methods, but they did not directly measure the diversity, frequency, or population of plant-parasitic nematodes present in the crop.

To the extent that plant health and agricultural sustainability are concerned, an evaluation of the phytosanitary risk presented by plant-parasitic nematodes is one of the areas in which the planning of integrated management strategies within vineyards is concerned in a design-oriented manner. Such international bodies as the FAO and the OIV highlighted the necessity to produce local data on soilborne pathogens to estimate the extent of the infestation and its possible effects on crop production and life (FAO, 2021; OIV, 2023). In this regard, the awareness of the diversity, prevalence, and intensity of plant-parasite nematodes existing in rhizospheric soils is a basic tool of agronomic decision-making and the representation of preventive and rectifying action, based on the principles of integrated management.

In this regard, it was the purpose of the current work to describe the diversity and population structure of plant-parasitic nematodes of grape (*Vitis vinifera* L.) crops in La Union and Toro municipalities, Valle del Cauca, by morphological identification and investigation of the characteristics of populations, to estimate the level of phytosanitary risk and create the technical bases to facilitate the design of the integrated management options to achieve the sustainability of local grape production.

The produced information will be added to the literature on the region nematology and also offer technical standards of the agronomic decision-making that is aimed at averting and alleviating the effects of plant-parasitic nematodes in the production systems of vineyards.

## 2. MATERIALS AND METHODS

Six grape production areas in the municipalities of La Union and Toro, along the northwestern area of the department of Valle del Cauca, Colombia, were sampled. There were five plots that were affiliated with the farm of Mr Alberto Lisi Sabal, in the municipality of La Union and one plot of Palma Farm, in the municipality of Toro. The research site lies at an estimated altitude of 900-1100m above sea level and has a climate of warm temperate weather with a mean annual temperature of 23-26 °C, a mean of 1200-1500mm annual rainfall, and a bimodal precipitation pattern. The soils are mainly alluvial in origin, have a sandy loam to clay loam texture, have good natural drainage, and a low or moderate level of organic matter, soils that are favourable to both the establishment of grapevine cultivation and development and maintenance of plant-parasitic nematode communities in the rhizosphere.

### 2.1. Sampling

In both plots, a total of 1kg of soil and fine roots were sampled in the rhizosphere (active root zone), which was sampled at 0-30 cm. Composite soil and root samples were taken as described in the article by Marquez *et al.* (2020). To select the sampling points, preference was given to grape plants that were less vigorous or less fruitful, under the observation of the field assistant. Further, the crop rows were sampled in a zigzag pattern with ten rows in between. The subsamples were then homogenized thus creating a single composite sample per plot. After all, the samples were packaged, labelled, and stored in refrigerated Styrofoam bottles to be processed in the microbiology laboratory of the Universidad del Pacifico (Marquez, 2020; Rodriguez, 2020).

### 2.2. Nematode Extraction from Soil Samples

The parasitic nematodes of plants were extracted from soil samples with the help of a modified method of agitation and decantation, which is described by Marquez (2020). Five replications of 100 g of soil were made as composite samples suspended in 1-2 litres of tap water each in case of each composite sample. Five minutes of rotational mixing were done so that the nematodes could be emancipated from the soil-rhizosphere complex. The suspensions were then left to settle in place during a period of about 10 seconds to allow the finer particles to settle, and the

suspension was then filtered by a series of sieves of 30, 270, 325 and 400 mesh. The sediment left on the 325 and 400 mesh sieves was washed into a beaker on facial tissue paper already laid on a decantation sieve. Lastly, the sieve that contained the retained material was put in a decantation tray with tap water and left unmixed for 48 hours to allow the migration and separation of the plant-parasitic nematodes to the bottom of the container, which would be recovered on to be analyzed later.

### 2.3. Extraction of Plant-Parasitic Nematodes from Root Samples

The plant-parasitic nematodes were removed from the composite root samples using the decantation and maceration technique, as suggested by Marquez (2020). Firstly, the tap water was used to wash the roots thoroughly to get rid of soil residues. Afterwards, 10 g of fine roots per sample was further subdivided into five replicates and mixed at a low speed in 200 ml of tap water to free the nematodes from the plant tissue without making them excessive.

The macerate obtained was filtered through 30, 270, 325 and 400 mesh sieves. The content held on the sieves of 325 and 400 mesh was pooled in a final volume of 100 ml and pooled onto facial tissue paper set up on a 12 cm diameter decantation sieve. This sieve was placed in a decantation tray with tap water and was left to stand without disturbance for 48 hours in order to allow the separation of the plant-parasitic nematodes.

The plant-parasitic nematodes were then collected in a 400 mesh sieve and pelleted in Falcon tubes down to a final volume of 20 ml and held at 4 °C until needed. Quantification and morphological identification were done according to the conventional taxonomic descriptions, with diagnostic characters including the shape and the length of stylet, the morphology of the lip region, the presence or absence of a median bulb, the shape of the tail, the posture during rest, and the type of cuticle among others (Avena *et al.*, 2019; Marquez, 2020; Arboleda, 2022).

### 2.4. Quantification of Plant-Parasitic Nematodes and Ecological Parameters

Measuring the plant-parasitic nematodes was conducted with the help of 3 ml aliquots of the obtained suspensions put in a counting chamber to analyze it with the microscope. The genera of the plant-parasitic nematodes that were found were determined by direct observation, and the abundance of each genus was noted. Three readings were made on independent samples on each replicate, and the values obtained were then averaged to minimize counting error.

According to the received data, several ecological and population measures were determined, such as absolute and relative frequency, absolute and relative density, and prominence value by genus, with the help of formulas provided in the specialized literature (Avena et al., 2019; Marquez, 2020). The parameters enabled the description of the structure of the plant-parasitic nematode communities related to grape growing and assessment of their possible phytosanitary risk within the research sites.

### 3. RESULTS AND DISCUSSION

In this research, 10 sampled populations of plant-parasitic nematodes (grape crops) were determined in the department of Valle del Cauca: five in the municipality of La Union (3 *Helicotylenchus*, 2 *Pratylenchus*) and five in Toro (3 *Helicotylenchus*, 2 *Pratylenchus*). The resemblance in the constitution of municipalities indicates that both genera enjoy positive agroecological conditions in the area, which is consistent with the reports of their common

occurrence in tropical and subtropical systems (Mo et al., 2021). According to authors like Arboleda et al. (2023), *Pratylenchus* is also not very mobile, and this would be the reason why this genus has not been detected in all samples received. The presence and diversity of plant-parasitic nematodes across localities could be directly dependent on factors and/or differences related to soil management, use of rootstock, or edaphauna and edaphoclimatic conditions (Neher, 2020; Mo et al., 2021).

The populations of the *Helicotylenchus* had a post-mortem spiral form, conoid tail, flattened bottom knobs, raised lip region, and no male-typical indicative features of this genus (Munawar et al., 2024; Uzma et al., 2016). Similarly, the populations of the *Pratylenchus* were described by a flattened lip zone, a spatulate tail, a filiform resting position, and a visible median bulb (Figure 1), which is compatible with the recent descriptions of the species of this genus attacking perennial crops (Castillo & Vovlas, 2019; Mo et al., 2021).

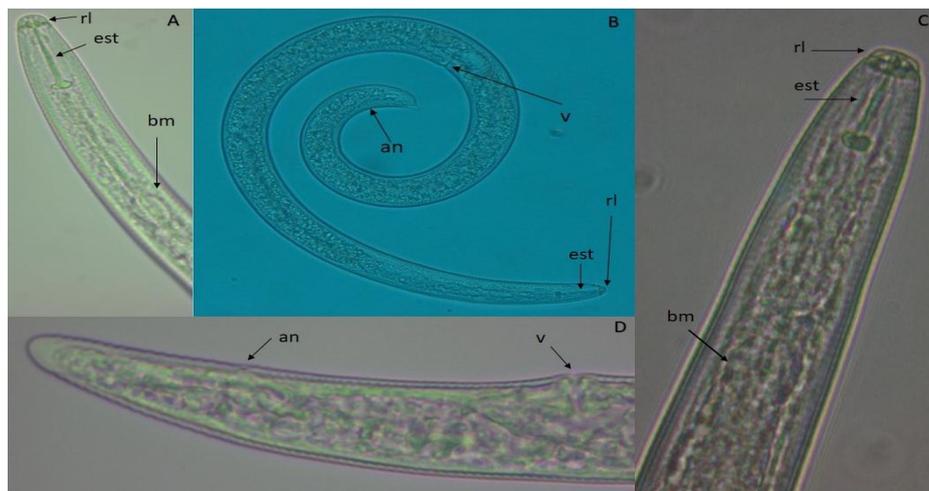


Figure 1: Plant-parasitic Nematodes.

A. Posterior region of *Helicotylenchus* sp., B. Adult female of *Helicotylenchus* sp. in resting position (spiral), C. Posterior region of *Pratylenchus* sp., D. Anterior region of *Pratylenchus* sp. rl = lip region, est = stylet, bm = median bulb, v = vulva, an = anus.

The presence of both genera is associated with coexistence with regard to phytosanitary. *Pratylenchus* comprises endoparasites that can migrate and induce root necrosis and nutrient uptake degradation (Castillo & Vovlas, 2019). *Helicotylenchus*, in its turn, is deemed a root-weakening nematode that can, when present in large quantities, cause a plant to become less vigorous and make it susceptible to secondary infections (Munawar et al., 2024). Research on other crops demonstrated that the complement of these genera

could lead to an increase in root damage and the impact on the life of the plantation (Mo et al., 2021).

The findings in the vineyards of Valle del Cauca indicated that the genera *Helicotylenchus* and *Pratylenchus* were the major plant-parasitic nematodes in the samples, with a population of free-living nematodes. *Helicotylenchus* was the most abundant (100% in soil and 100% in roots) and the most abundant relative (47.6 in soil and 37.5 in roots), indicating that it is widespread and adapts to the edaphic conditions of the region. *Pratylenchus*, on the other hand, was discovered with a relative frequency of 26.7 and 29.4 in soil and roots, respectively, with the free-living nematodes having a 35.3 and 33.3 percentage in soil and roots, respectively (Tables 1 and 2).

In the soils and roots, the genus *Helicotylenchus* had

an absolute frequency of 100 and relative frequency of 40 and 35.3, respectively, showing that this species was found in all the samples, hence becoming the dominant plant-parasitic nematode in the vineyards studied. This finding is applicable because it verifies the extensive distribution of this genus in agricultural soils of the tropical and subtropical regions (Munawar *et al.*, 2024; Riascos-Ortiz *et al.*, 2020). Conversely, *Pratylenchus* was relatively frequent with a frequency of 26.6 and free-living nematodes were 33.3, indicating a rather diverse nematode community.

*Helicotylenchus* indicated the highest value in the absolute density (per 100 g of soil) (13 individuals/100 g), followed by *Pratylenchus* (7) and free-living nematodes (7) (Table 3). This means that spiral nematodes not only predominate but are also abundant. This tendency is supported by its relative density (47.6%), which shows that it can be devastating in perennial crops, as observed in the works on *Musa* and grapevine (Mo *et al.*, 2021; Castillo and Vovlas, 2019). On the same note,

population levels in roots (10 g) were 9, 10, and 5 of *Helicotylenchus*, *Pratylenchus*, and free-living nematodes in roots, respectively (Tables 1 and 2).

There was also an absolute prominence value of *Helicotylenchus* (130), which was greater than that of *Pratylenchus* (59.6) and the free-living nematodes (63.9). The relative prominence value proves the pre-eminence of *Helicotylenchus* (0.51), whereas *Pratylenchus* and free-living nematodes were 0.24 and 0.25, respectively. Absolute prominence of *Pratylenchus*, *Helicotylenchus* and free-living nematodes in roots was 91.29, 90 and 50, respectively. The relative prominence value demonstrates that the relative performance of *Helicotylenchus* (0.39) is slightly better in this agroecosystem, whereas *Pratylenchus* was also 0.39 and free-living nematodes were 0.22. The parameters are primary since they indicate the capacity of each group to have stable populations in each local condition, indicating that *Helicotylenchus* is more adapted to the local agroecosystems of Valle del Cauca that are viticultural (Riascos-Ortiz *et al.*, 2020).

**Table 1: Ecological Parameters for Soil Populations**

GRAPE ( <i>Vitis vinifera</i> )						
Genera	Absolute Frequency (%)	Relative Frequency (%)	Absolute Density (100 g/soil)	Relative Density (%)	Absolute Prominence Value	Relative Prominence Value
<i>Helicotylenchus</i>	100,00	40,00	13,00	47,62	130,00	0,51
<i>Pratylenchus</i>	66,67	26,67	7,30	26,74	59,60	0,24
Free-living	83,33	33,33	7,00	25,64	63,90	0,25
	250	100	27,3	100	254	1

**Table 2: Ecological Parameters for Root Populations**

GRAPE ( <i>Vitis vinifera</i> )						
Genera	Absolute Frequency (%)	Relative Frequency (%)	Absolute Density (10 g/root)	Relative Density (%)	Absolute Prominence Value	Relative Prominence Value
<i>Helicotylenchus</i>	100,00	35,29	9,00	37,50	90,00	0,39
<i>Pratylenchus</i>	83,33	29,41	10,00	41,67	91,29	0,39
Free-living	100,00	35,29	5,00	20,83	50,00	0,22
	283	100	24	100	231	1

**Table 3: Population Levels based on 100 Grams of Soil and 10 Grams of Roots**

Population level in soil (100 g)				Population level in roots (10 g)			
	<i>Helicotylenchus</i>	<i>Pratylenchus</i>	Free-living		<i>Helicotylenchus</i>	<i>Pratylenchus</i>	Free-living
Toro	8	0	5	Toro	5	7	4
	12	15	6		10	19	6
	16	6	4		8	7	2
La Unión	20	9	10	La Unión	15	7	12
	17	14	19		14	21	4
	7	0	0		3	0	1

The free-living nematodes, regarding the questions of their significant frequencies and

densities are of interest as bioindicators of soil health, because they are involved in the process of



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