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Phytonematodes Associated with Kenaf (*Hibiscus cannabinus* L.) in Southwest Nigeria

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Abstract

The study identified the plant-parasitic nematodes associated with kenaf in selected locations in southwest Nigeria. A survey was conducted in kenaf fields in Ile-Ife and Ikenne, Ibadan and Ilora in September, 2022. The soil sampling procedure involved the collection of samples from 30 distinct locations proximate to the plant roots. Plant-parasitic nematodes (PPNs) were extracted, identified and counted. The frequency of occurrence (FO) and population densities (PD) of the extracted nematodes were calculated. Four genera of PPNs were associated with kenaf in all study locations. These were *Meloidogyne*, *Pratylenchus*, *Helicotylenchus*, and *Tylenchus*. In Ile-Ife, *Meloidogyne* had the highest population density per 200 ml soil (72.7%), followed by *Helicotylenchus* (21.4%), while the lowest density was recorded for *Tylenchus* (2.0%). In Ikenne, the highest density was recorded for *Meloidogyne* (47.3%), followed by *Pratylenchus* (27.9%), and *Helicotylenchus* (24.4%). The lowest nematode density was recorded for *Tylenchus* (0.5%). In Ilora, the highest density was recorded for *Meloidogyne* (66.9%), followed by *Helicotylenchus* (23.9%), while the lowest density was recorded for *Tylenchus* (1.4%). The survey in Ibadan showed that nematode with the highest density was *Meloidogyne* (61.1%), followed by *Helicotylenchus* (28.0%), while the least density was recorded for *Tylenchus* (1.3%). This study concluded that four genera of PPN were associated with kenaf in Ikenne, Ile-Ife, Ilora and Ibadan. These were *Meloidogyne*, *Helicotylenchus*, *Pratylenchus* and *Tylenchus*. The most abundant was *Meloidogyne*. Therefore, in the management of PPN genera that may impact kenaf production in southwest Nigeria in kenaf, more emphasis should be placed on root-knot nematodes.

Keywords: kenaf, plant-parasitic nematodes, frequency of occurrence, nematode density, *Meloidogyne*

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Fitonematodos asociados al kenaf (*Hibiscus cannabinus* L.) en el sudoeste de Nigeria

Resumen

El estudio identificó los nematodos fitoparásitos asociados al kenaf en localidades seleccionadas del suroeste de Nigeria. Se realizó un muestreo en campos de kenaf en Ile-Ife e Ikenne, Ibadan e Ilora en septiembre de 2022. El procedimiento de muestreo de suelo consistió en la recolección de muestras en 30 puntos distintos cercanos a las raíces de las plantas. Se extrajeron, identificaron y contabilizaron los nematodos fitoparásitos (NFP). Se calcularon la frecuencia de ocurrencia (FO) y las densidades de población (DP) de los nematodos extraídos. Cuatro géneros de NFP se encontraron asociados al kenaf en todas las localidades del estudio: *Meloidogyne*, *Pratylenchus*, *Helicotylenchus* y *Tylenchus*. En Ile-Ife, *Meloidogyne* presentó la mayor densidad de población por cada 200 ml de suelo (72,7%), seguido por *Helicotylenchus* (21,4%), mientras que la densidad más baja se registró para *Tylenchus* (2,0%). En Ikenne, la mayor densidad fue para *Meloidogyne* (47,3%), seguido de *Pratylenchus* (27,9%) y *Helicotylenchus* (24,4%). La densidad más baja de nematodos se registró para *Tylenchus* (0,5%). En Ilora, la densidad más alta correspondió a *Meloidogyne* (66,9%), seguida de *Helicotylenchus* (23,9%), con la menor densidad para *Tylenchus* (1,4%). El muestreo en Ibadan mostró que el nematodo con mayor densidad fue *Meloidogyne* (61,1%), seguido de *Helicotylenchus* (28,0%), mientras que la menor densidad fue para *Tylenchus* (1,3%). Este estudio concluyó que cuatro géneros de NFP están asociados al kenaf en Ikenne, Ile-Ife, Ilora e Ibadan. Estos fueron *Meloidogyne*, *Helicotylenchus*, *Pratylenchus* y *Tylenchus*. El más abundante fue *Meloidogyne*. Por lo tanto, en el manejo de los géneros de NFP que pueden afectar la producción de kenaf en el suroeste de Nigeria, se debe poner mayor énfasis en los nematodos del nódulo radical (*Meloidogyne*).

Palabras clave: kenaf, nematodos fitoparásitos, frecuencia de ocurrencia, densidad de nematodos, *Meloidogyne*

Fitonematoides associados ao kenaf (*Hibiscus cannabinus* L.) no sudoeste da Nigéria

Resumo

O estudo identificou os nematoides fitoparasitas associados ao kenaf em localidades selecionadas no sudoeste da Nigéria. Um levantamento foi realizado em campos de kenaf em Ile-Ife e Ikenne, Ibadan e Ilora em setembro de 2022. O procedimento de amostragem de solo envolveu a coleta de amostras em 30 locais distintos próximos às raízes das plantas. Os nematoides fitoparasitas (NFPs) foram extraídos, identificados e contados. A frequência de ocorrência (FO) e as densidades populacionais (DP) dos nematoides extraídos foram calculadas. Quatro gêneros de NFPs foram associados ao kenaf em todos os locais de estudo. Estes foram *Meloidogyne*, *Pratylenchus*, *Helicotylenchus* e *Tylenchus*. Em Ile-Ife, *Meloidogyne* apresentou a maior densidade populacional por 200 ml de solo (72,7%), seguido por *Helicotylenchus* (21,4%), enquanto a menor densidade foi registrada para *Tylenchus* (2,0%). Em Ikenne, a maior densidade foi registrada para *Meloidogyne* (47,3%), seguido por *Pratylenchus* (27,9%) e *Helicotylenchus* (24,4%). A menor densidade de nematoides foi registrada para *Tylenchus* (0,5%). Em Ilora, a maior densidade foi de *Meloidogyne* (66,9%), seguida por *Helicotylenchus* (23,9%), enquanto a menor densidade foi de *Tylenchus* (1,4%). O levantamento em Ibadan mostrou que o nematoide com a maior densidade foi *Meloidogyne* (61,1%), seguido por *Helicotylenchus* (28,0%), enquanto a menor densidade foi registrada para *Tylenchus* (1,3%). Este estudo concluiu que quatro gêneros de NFPs estavam associados ao kenaf em Ikenne, Ile-Ife, Ilora e Ibadan. Estes foram *Meloidogyne*, *Helicotylenchus*, *Pratylenchus* e *Tylenchus*. O mais abundante foi o *Meloidogyne*. Portanto, no manejo de gêneros de NFPs que podem impactar a produção de kenaf no sudoeste da Nigéria, deve-se dar maior ênfase aos nematoides de galhas (*Meloidogyne*).

Palavras-chave: kenaf, nematoides fitoparasitas, frequência de ocorrência, densidade de nematoides, *Meloidogyne*

1. Introduction

Kenaf is an important fibre crop grown in tropical and sub-tropical climates (Ogunniyan et al., 2018). It is a fibre crop that had its origin in east-central Africa. Taxonomically, it is a member of the family Malvaceae, sharing the same family with okra and cotton (Izran et al., 2014). It is cultivated in nations including Malaysia, India, and China (Basri et al., 2014). This crop thrives well in regions with much sunlight and water. The plant is capable of growing to 5 m tall (Ayadi et al., 2017). Kenaf has physical features such as large, bell-shaped yellow or purple flowers. Each of the corollas bear five petals. It has a high yielding and stress resistance potentials, making it very adaptable to diverse environments (Vayabari et al., 2023).

Kenaf is primarily grown for its fibre, which is derived from its stem. An average of thirty tonnes of dry fibre can be produced from a hectare. The fibre is mainly used for industrial purposes such as pulp and paper production, bio-composite manufacturing and textile production (Afzal et al., 2022; Akinrotimi & Okocha, 2018; Xu et al., 2013). The use of kenaf for other purposes such as health management in humans and animals has also gained recognition (Kujoana et al., 2023).

In India, between the years 2014 and 2015, approximately 46% of the global kenaf output was recorded, while China contributed with 26%. Pakistan accounted for 0.46%, 1.6% was contributed by Indonesia, and Africa collectively contributed 6.8% (Alexopoulou et al., 2015). Within Africa, specific countries had varying contributions to this production. For instance, Nigeria represented 9%, Mali 9%, Angola 5%, Mozambique 22%, South Africa 5%, and Ethiopia 3% (Food and Agriculture Organization of the United Nations [FAO], 2022). Nigeria stands as one of the prominent kenaf producers within the African continent. On a global scale, Africa is still at the initial phase of recognizing kenaf as a viable industrial crop due to its low annual production level. As at 2020, the official estimate for Nigeria's total kenaf fibre crop output reached approximately 1,460 tonnes. The worldwide kenaf output for 2020 was roughly estimated at 230,803 tonnes (FAO, 2022). The cultivation of kenaf is primarily concentrated in Nigeria's southwestern states, particularly Ogun and Oyo, which collectively contribute about 60% of the nation's overall production (National Agricultural Extension and Research Liaison, 2019).

Kenaf cultivation in Nigeria faces several significant challenges. These include viral, fungal and plant-parasitic nematode diseases (Adegbite, 2017; Kareem et al., 2021; Oduwaye & Olanipekun, 2024). Studies have shown that PPNs are important in the production of kenaf. Plant-parasitic nematodes identified as *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, *Tylenchus* and *Scutellonema* were reported to be associated with kenaf in south-south Nigeria (Tanimola et al., 2020). Furthermore, in a three-year study (1989, 1990 and 1991) carried out in Haskell, Oklahoma, the presence of *Pratylenchus* and *Helicotylenchus* in kenaf field was documented. These nematodes pose a risk to kenaf, varying across different locations (Webber, 1999). The variation is caused by compound interactions including the specific disease dynamics, the cultivated kenaf varieties, and the prevailing environmental conditions (Adegbite, 2017). The accomplishment of any successful plant-parasitic nematode management approach depends on accurate identification of the associated nematodes. This study was conducted to determine the predominant plant parasitic nematode associated with kenaf production in selected locations in southwest Nigeria.

2. Materials and Methods

2.1 Sampling Sites and Procedures

Soil samples were collected in a hectare-field per location in kenaf cultivation sites of Ifeken 400 in Ibadan 7°37'N, 3°85'E, 182 m alt. and Ilora 07°81' N, 03°82' E, 278 m alt. (representing derived savannah region) as well as Ile-Ife 7°28ˈN, 4°33ˈE, 244 m alt. and Ikenne 06°85 N, 003°70' E, 70 m alt. (representing rainforest

region) in September, 2022. The fields have been repeatedly used to cultivate kenaf in the previous 5-7 years. The average weather conditions in the locations in the period of study are shown in Table 1. A total of 30 subsamples proximate to the plant roots 0-15 cm deep were collected from each location following a pattern resembling three interlinked "W" shapes or a zigzag arrangement. The plants were eight weeks old when the samples were collected. Each soil subsample comprised 30 cores that form a composite sample of about 1 kg from which 200 ml soil was drawn for nematode extraction. These soil samples were carefully deposited in plastic bags. The samples were refrigerated at a temperature of 4 °C till the nematode extraction process was conducted.

Table 1. Climatic conditions in southwestern Nigeria (September 2022)

Location	Avg Temp (°C)	Rainfall (mm)	Rainy Days	Humidity (%)
Ile-Ife	25	237	25	90
Ikenne	26	210-266	22	91
Ilora	26-27	279	22	90
Ibadan	25	279	23	90

Source. National Oceanic and Atmospheric Administration (2022).

2.2 Extraction of Nematodes and Identification

Nematode extraction was carried out following the modified Baermann procedure (Whitehead & Hemming, 1965). The counting of nematode was done utilizing a stereomicroscope (×250 magnification), following the counting dish method (Doncaster, 1962).

2.3 Morphological Identification of Nematodes

Nematodes from the soil samples were individually examined at ×400 magnification. The identification of the nematodes, including their genera, was based on the morphological characteristics (Mai & Lyon, 1975).

2.4 Data Analysis

The frequency of occurrence (FO) and population densities (PD) of the extracted nematodes were calculated using the following formulas: Percentage frequency of occurrence (FO) = (n / N) × 100, where n = Number of soil samples containing a particular genus, N = Total number of samples. Percentage population densities (PD) = (In / TN) × 100, where In = number of nematodes of the genus considered extracted from the samples, and TN = total number of nematodes extracted from the samples.

3. Results

Four genera of plant-parasitic nematodes were identified in each of the selected locations in southwest Nigeria, including Ile-Ife, Ibadan, Ilora, and Ikenne. These nematodes were *Meloidogyne*, *Helicotylenchus*, *Pratylenchus* and *Tylenchus*, which are classified as shown in Table 2.

In Ile-Ife, *Meloidogyne* had the highest frequency of occurrence (100%), followed by *Helicotylenchus* (96.7%), while the lowest frequency of occurrence was recorded for *Tylenchus* (30%). Also, *Meloidogyne* had the highest density per 200 ml soil (72.7%), followed by *Helicotylenchus* (21.4%), while the lowest density was recorded for *Tylenchus* (2.0%) (Table 3).

In Ilora, the highest frequency of occurrence was recorded for *Meloidogyne* and *Helicotylenchus* (100%), followed by *Pratylenchus*, that recorded 90%, while *Tylenchus* recorded 40%. The highest density was recorded

for *Meloidogyne* 66.9%, followed by *Helicotylenchus* (23.9%), while *Tylenchus* recorded the lowest density (1.4%) (Table 4).

In Ibadan, the highest frequency of occurrence was recorded for *Meloidogyne* and *Helicotylenchus* (100%), followed by *Pratylenchus* (90%), while the lowest was recorded for *Tylenchus* (50%). The nematode with highest density was *Meloidogyne* (61.1%), followed by *Helicotylenchus* (28.0%), while the least density (1.3%) was recorded for *Tylenchus* (Table 5).

In Ikenne, the frequencies of occurrence of *Meloidogyne*, *Helicotylenchus* and *Pratylenchus* were 100%, while 36% was recorded for *Tylenchus*. The nematode with highest density was *Meloidogyne* (47.3%), followed by *Pratylenchus* (27.9%), and *Helicotylenchus* (24.4%). The lowest nematode density of 0.5% was recorded for *Tylenchus* (Table 6).

Table 2. Classification of plant-parasitic nematodes identified at the study sites

Order	Suborder	Superfamily	Family	Subfamily	Genus
Rhabditida	Tylenchina	Tylenchoidea	Meloidogynidae	Meloidogyninae	*Meloidogyne*
			Tylenchidae	Tylenchidae	*Tylenchus*
			Hoplolaimidae	Hoplolaiminae	*Helicotylenchus*
			Pratylenchidae	Pratylenchinae	*Pratylenchus*

Source. Hunt et al. (2005) and Perry and Moens (2013).

Table 3. Frequency of occurrence and relative abundance of plant-parasitic nematodes associated with kenaf in Ile-Ife

Genus	Frequency of occurrence	Percentage frequency of occurrence	Population density of nematode per 200 ml soil	Percentage nematode density
Meloidogyne	30	100	112	72.7
Helicotylenchus	29	96.7	33	21.4
Pratylenchus	16	53.3	6	3.9
Tylenchus	9	30	3	2.0

n/N × 100 (n = number of samples containing a genus and N = sample size (30)).

In/TN × 100 (In = number of nematodes of the genus considered extracted from the samples and TN = total number of nematodes extracted from the samples).

Table 4. Frequency of occurrence and relative abundance of plant-parasitic nematodes associated with kenaf in Ilora

Genus	Frequency of occurrence	Percentage frequency of occurrence	Population density of nematode per 200 ml soil	Percentage nematode density
Meloidogyne	30	100	95	66.9
Helicotylenchus	30	100	34	23.9
Pratylenchus	27	90	11	7.7
Tylenchus	12	40	2	1.4

n/N × 100 (n = number of samples containing a genus and N = sample size (30)).

In/TN × 100 (In = number of nematodes of the genus considered extracted from the samples and TN = total number of nematodes extracted from the samples).

Table 5. Frequency of occurrence and relative abundance of plant-parasitic nematodes associated with kenaf in Ibadan

Genus	Frequency of occurrence	Percentage frequency of occurrence	Population density of nematode per 200 ml soil	Percentage nematode density
Meloidogyne	30	100	96	61.1
Helicotylenchus	30	100	44	28.0
Pratylenchus	27	90	15	9.6
Tylenchus	15	50	2	1.3

n/N × 100 (n = number of samples containing a genus and N = sample size (30)).

In/TN × 100 (In = number of nematodes of the genus considered extracted from the samples and TN = total number of nematodes extracted from the samples).

Table 6. Frequency of occurrence and relative abundance of plant-parasitic nematodes associated with kenaf in Ikenne

Genus	Frequency of occurrence	Percentage frequency of occurrence	Population density of nematode per 200 ml soil	Percentage nematode density
Meloidogyne	30	100	95	47.3
Helicotylenchus	30	100	49	24.4
Pratylenchus	30	100	56	27.9
Tylenchus	11	36	1	0.50

n/N × 100 (n = number of samples containing a genus and N = Sample size (30)).

In/TN × 100 (In = number of nematodes of the genus considered extracted from the samples and TN = total number of nematodes extracted from the samples).

4. Discussion

This study identified four genera of plant-parasitic nematodes associated with kenaf across all locations surveyed. These were *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, and *Tylenchus*. These nematode genera were also observed in kenaf cropping systems within southwestern Nigeria's humid rainforest, derived savannah, and Northern Guinea savannah agroecological zones. *Aphelenchus*, *Scutellonema*, *Hoplolaimus*, and *Rotylenchulus* (Adegbite, 2017), which were not documented in this study, were also identified. In a related study, in south-south Nigeria, *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, *Tylenchus* and *Scutellonema* were also reported in kenaf field (Tanimola et al., 2020). The presence of other plant-parasitic nematodes not documented in the present study might be due to the varying prevailing agronomic practices, cropping history, soil type and the environmental factors in the locations of study.

Furthermore, in a three-year study (1989, 1990 and 1991) carried out in Haskell, Oklahoma, the presence of *Pratylenchus*, *Helicotylenchus*, *Xiphinema, Hoplolaimus*, and *Tylenchorhynchus* was documented in kenaf field (Webber, 1999). The identification of *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, and *Tylenchus* in this study across different locations and agroecologies is an indication that certain plant parasitic nematodes are more adaptive to specific environmental conditions than others.

This study identified *Meloidogyne* as the most important genus of plant-parasitic nematodes associated with kenaf. Studies have shown *Meloidogyne* as the major nematode pest of kenaf (Adegbite, 2017; Tahery et al., 2011). The association of kenaf with root-knot nematodes has been reported in different parts of the world. The severity of the nematode on the growth and yield of certain varieties of kenaf has been reported (Adegbite et al., 2005). The significance of *Meloidogyne* as the dominant plant-parasitic nematode associated with kenaf was further emphasized in a need to determine the appropriate selection model for the plant resistance to the

nematode (Parnidi et al., 2021). Root-knot nematodes have been reported as significant pests in kenaf cultivation in both Europe and China (Alexopoulou et al., 2015). A selected number of kenaf varieties, including AU 64, Ex-Funtua, Ifeken 100, G 45, Ifeken 400, Tianung 1, and Cuba 108 screened for *Meloidogyne incognita* in a two-year study (2006 and 2007) confirmed the relationship with the nematode (Adegbite et al., 2008). These findings highlighted the importance of breeding and selecting plant parasitic nematode-resistant kenaf varieties to minimize economic losses and sustain kenaf production.

5. Conclusions

The results of this study established that four genera of PPN were linked to kenaf in Ikenne, Ile-Ife, Ilora and Ibadan: *Meloidogyne*, *Helicotylenchus*, *Pratylenchus*, and *Tylenchus*. The predominant and the most important of all was *Meloidogyne*. Therefore, in the management of PPN in kenaf, much attention should be given to *Meloidogyne*, without neglecting other PPNs. Results from this survey will help the kenaf farmers in the agricultural communities to understand plant parasitic nematodes associated with the crop and prioritize management.

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Transparency of Data

Data not available: The data set that supports the results of this study is not publicly available.

Author Contribution Statement

	AA Adesuyi	F Daramola	E Ezaka	OK Adekunle
Conceptualization	■	■		■
Investigation	■	■		■
Methodology	■	■	■	■
Writing – original draft	■			
Writing – review and editing	■	■	■	■

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