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Plant parasitic nematodes associated with oil palm trees in three regions of Ghana

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ABSTRACT

Field surveys were conducted in three oil palm producing regions of Ghana to determine the frequency, population density and geographical distribution of plant parasitic nematodes associated with oil palm. Palms ranging from 4 to 12 years were surveyed during the peak periods of two successive cropping seasons of 2019 and 2020. A total of 64 soil and root samples were collected and plant parasitic nematodes extracted and identified from them. 716 mixed populations of 11 economically important plant-parasitic nematode genera were recovered and identified from both roots and soils during the period. These were *Aphelenchus*, *Criconemoides*, *Helicotylenchus*, *Hemicriconemoides*, *Meloidogyne*, *Pratylenchus*, *Radopholus*, *Rotylenchus*, *Tylenchorynchus*, *Tylenchus* and *Xiphinema*. *Meloidogyne* and *Pratylenchus* were the most frequently isolated and widely distributed geographically. *Meloidogyne* recovered from both soil and roots were 220 while *Pratylenchus* recovered were 129. These nematodes are very important pests of several crops, therefore, if not managed properly, could pose a threat to oil palm production in Ghana.

Keywords: *Elaeis guineensis*; nematodes; prevalence; distribution; survey

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Introduction

The oil palm (*Elaeis guineensis* Jacq.) is a major oil-producing crop, accounting for more than half of the global vegetable oil trade (Boons & Mendoza, 2010)It is the world's most productive oil crop per acre (Verheye, 2010). In Ghana, its farming in the forest zone contributes significantly to the economy in terms of jobs and foreign exchange, coming in second only to cocoa.

Many pests and diseases, however, have been found to harm oil palms across the world (Maluin *et al*., 2020). In Ghana, particularly in the Western, Central and Eastern Regions where optimal areas for oil palm cultivation are found, oil palm is faced with damage of pests and diseases (Rhebergen *et al*., 2020). The common insect pests of oil palm in Ghana are the oil palm leaf

miner (*Coelaenomenodera lameensis* Berti & Mariau), red palm weevil (*Rhynchophorus* spp.) and rhinocerous beetle (*Oryctes rhinoceros* Linneaus) (Agrios, 2015). The most common fungal diseases include bunch rot (*Marasmius palmivorus* Sharples), Bud Rot disease (*Phytophthora palmivora* Butler), Basal Stem Rot (*Ganoderma*), and Vascular Wilt (*Fusarium oxysporum* f.sp elaeidis) (Agrios, 2015). The bacterial Bud Rot/ Spear Rot (*Erwinia* spp) is a common bacterial disease of oil palm in Ghana. In Ghana, there is little or no knowledge of plant-parasitic nematodes associated with the crop as well as its economic importance.

Plant-parasitic nematodes are considered one of the most significant groups of pathogens worldwide, responsible for yearly agricultural losses of more than $100 billion (Agrios, 2012). Aside from direct production losses caused by their parasitism, several nematode species exacerbate losses caused by other pests and diseases. The initial quantity of nematodes in the soil is frequently connected to nematode damage to most crops. Farmers find it difficult to detect nematode infections and damage, let alone treat it, because below-ground infestations that lead to above-ground symptoms are difficult to detect. The goal of this research was to identify plant parasitic nematodes associated with oil pam trees and determine their frequency of occurrence, population densities, and geographic distribution in Ghana.

Materials and Methods

Field surveys and sample collection

Soil and root samples were collected during surveys in the Central, Western, and Eastern regions of Ghana. For two years in a row, each region was assessed during the main farming season, which runs from February to June. In each region, five of the highest oilpalm producing towns were randomly selected and samples collected from two farms in each town. 4 to 12 year-old farms were sampled in each town. A portable GPS device (Garmin eTrex 20, Switzerland) was used to record the GPS coordinates of each farm (Table 1).

TABLE 1
GPS coordinates of towns from which soil and root samples were collected

Region	Town	GPS coordinates	Age of palms
Western	Aboasu	7° 13’ 59.98”N 1 ° 51’ 0.00”W	5
	Atieku	5 ° 33’ 39.00”N 1 ° 41’ 16.00”W	4
	Bogoso	5 ° 34’ 7.82”N 2 ° 0’ 22.79”W	8
	Dramang	5 ° 30’ 39.00”N 1° 50’ 49.00”W	7
	Huni valley	5° 28’ 16.91”N 1° 5451.87”W	6
Eastern	Adonkrono	6° 04’ 54.91”N 0° 49’ 42.12”W	4
	Asuom	6° 15’ 48.13”N 0°52’ 26.14”W	8

	Kusi	6° 01' 40.00"N 0°51; 34.00"W	6
	Okumaning	6° 06' 57.00"N 0°53' 18.00"W	4
	Subi	6° 07' 48.51"N 0° 50' 6.47"W	10
Central	Burukuso	5° 25' 19.10"N 1° 27' 53.00"W	12
	Kyiabobso	5° 26' 21.00" N 1° 28' 25.00"W	6

The rhizosphere of oil palm plants was sampled with an auger up to a depth of 25 to 30 cm in a random pattern. Three sub-samples, each containing around 150 cm^3 soil, were collected and pooled from trees in each field. Tree roots were also obtained at the same time from the same locations as in soil and was combined in the same sample bag, so that the soil helps to preserve the roots. After collection, samples were placed on ice in an insulated ice chest to keep sample temperatures below 5°C and transported to the laboratory. All samples were placed in a refrigerator for three days before nematode extraction.

Nematode extraction

The extraction tray method (Coyne, 2007) and the sieving-sucrose centrifugation method (Van Bezooijen, 2006) were used to achieve successful extraction of both sluggish and mobile nematodes from soil. In the extraction tray method, two-ply tissue paper was put in a plastic basket (18 cm diameter; 6.5 cm depth) such that the tissue paper covered the whole base of the basket. A 100 ml beaker was used to measure 100 ml of well mixed and sieved soil sample. The measured soil sample was deposited and gently distributed over the tissue paper in the basket. The soil sample basket was put in another basket and then placed in an extraction plate (20 cm diameter; 3 cm deep). 200 ml tap water was carefully poured into the setup through the space between the plate's edge and the basket's edge and left for 48 hours. Setups were checked on a regular basis to ensure that plates that were drying out were refilled with water. The extraction plate suspension was emptied into a marked beaker after the 48 hours, and the plate was washed using a wash bottle into the beaker.

Nematodes were extracted from the residual soil sample by the sucrose centrifugation method. The soil was mixed with 500 ml water, spun and allowed to settle for 15 seconds. The supernatant was passed through an 833 mm/25 mm stacked sieve. The contents of the 25 mm sieve were carefully washed into a designated 50 ml centrifuge tube and equalized with tap water to the 50 ml mark. The tubes were placed in four pairs in a MR 23i benchtop centrifuge (Jouan-Thermo Scientific, U.S.A.). Samples were spun at 1700 rpm without brake for five minutes and then allowed to settle for five minutes. The supernatant was aspirated to a height of about 1 cm above the particle. Sucrose solution (454 g of sugar in 1l of distilled water) was added to the tube to

50 ml and spun again to 1000 rpm in 30 seconds before applying the brake. The supernatant was put through a 25 mm sieve, and the nematodes caught in the sieve were carefully deposited into vials with labels. For each sample, nematode aliquots from the extraction tray and sucrose centrifugation procedures were combined and diluted to 100 ml.

A 5 ml aliquot was sucked with a pipette and placed into a clean counting tray and counted using a tally counter under an inverted compound microscope (Exacta-OptechBiostar B5P, Germany). Counting was done twice at a magnification of 20×. Endo-parasitic nematodes were extracted from infested oil palm tree roots by the root maceration and modified Baermann funnel methods (Hooper, 1986). The roots were cut into one centimetre piece each. 10 grammes of the cut pieces was placed in a glass funnel lined with two-ply tissue paper set on a wire mesh. The funnel was corked to trap the water containing nematodes. The water was put separately into 250 ml beakers after the funnels had been left for 48 hours.

Identification of nematodes

The extracted nematodes were viewed under a compound light microscope (Exacta-Optech Biostar B5P, Germany) linked to a computer running image-scope professional software (version 12.6.5) by Roper technologies, U.S.A. Nematodes were identified to the genus level based on morphological characteristics. Recent taxonomic keys (Dasgupta *et al*., 1969; Handoo & Golden, 1989, Robinson *et al*., 1997; Handoo, 2000) and the University of Nebraska Lincoln nematode identification website (https://nematode.unl.edu/key/nemakey.htm) were used to validate the identifications.

Data analysis

Occurrence, population density of nematodes per 100 cm^3 of soil and 10 g root samples and distribution of nematodes were recorded as follows: Occurrence (%) = (number of farms containing a particular genus /total number of farms sampled) × 100; Population density = average number of nematodes per 100 cm^3 of soil and 10 g root samples; Distribution = the number of regions from which a particular nematode genus was found (Lutuf *et al*., 2018).

Results and Discussion

Nematodes from 11 genera were found in association with oil palm (Table 2). Some genera of nematodes were often found occurring in combinations at low population levels irrespective of the region. Mani *et al.*, (2005) reported a similar trend in a study of nematodes associated with date palms in Oman.

A total 716 nematodes were recovered from both roots and rhizosphere soils during the period. 14 *Aphelenchus* were found in one farm in the Eastern Region. This nematode has been found to feed on algae, mosses, lichens and plant roots (Yeates *et al*., 1993) and, therefore,

pose little threat to oil palm production. 25 *Criconemoides* were recovered from soils and 36 from roots of oil palm trees from four farms in the Eastern and Central Regions. 27 *Rotylenchus* were retrieved from soils and three from roots of oil palm trees from eight farms in the Central Region. 63 *Helicotylenchus* were found in soils and 12 from roots of oil palm trees from 12 farms in all three regions surveyed.

26 *Hemicriconemoides* were recovered from soils and 21 from roots in the Western and Central Regions. 162 *Meloidogyne* were found in soils and 58 from roots of oil palm trees from 18 farms in all three regions. This nematode (*Meloidogyne*) has been reported as the most damaging species affecting many crops worldwide (Sasser, 1987). 86 *Pratylenchus* were recovered from soils and 43 from roots of oil palm trees from 14 farms in the three regions. 52 *Radopholus* were retrieved from soils and 35 from roots of oil palm trees from seven farms in only Western Region, whilst 16 *Tylenchorynchus* were recovered from soils and two from roots in one farm in the Eastern and Western Regions. 23 *Tylenchus* were recovered from only soils from four farms in the Eastern and Western Regions. 12 *Xiphinema* were recovered from only soils from two farms in the Central Region.

Guevara *et al*. (1995) studied the presence of nematodes and found the nematodes *Helicotylenchus*, *Paratylenchus, Criconemella*,*Longidorus* , *Tylenchorhynchus* and *Xiphinema* present in roots of palms affected by but rot disease. *Helicotylenchus*, *Meloidogyne* and *Pratylenchus* were the major plant parasitic nematode genera most frequently recovered, most widely distributed and had the highest population densities compared to other genera. Despite the low quantities of nematodes found in this survey, interaction between plant-parasitic nematodes and other plant-pathogenic soil organisms, notably fungus and bacteria, in the establishment of disease complexes makes them highly important even at low densities. As a result, if these nematodes are not controlled, they may present a threat to Ghana's oil palm industry.

TABLE 2

Occurrence, population density and distribution of plant-parasitic nematodes associated with oil palm in Ghana

Nematode Genus	Occurrence (%)	Population/100cm^3 soil	Population/ 10g roots	Distribution
Aphelenchus	3.3	14	0	Eastern Region
Criconemoides	13.3	25	36	Eastern and Central Regions
Rotylenchus	26.6	27	3	Central Region
Helicotylenchus	40.0	63	12	Eastern, Central and Western Regions
Hemicriconemoides.	26.6	26	21	Central and Western Regions
Meloidogyne	60.0	162	58	Eastern, Central and Western Regions
Pratylenchus	46.6	86	43	Eastern Central and Western Regions
Radopholus	23.3	52	35	Western Region
Tylenchorynchus	3.3	16	2	Eastern and Western Regions
Tylenchus	13.3	23	0	Eastern and Western Regions
Xiphinema	6.6	12	0	Central Region
TOTAL		506	210	

Conclusion and Recommendation

A survey of oil palm fields in the optimal areas of the Eastern, Central and Western Regions of Ghana led to the identification of eleven nematode genera in association with oil palm. The frequency, population densities, and geographic distribution of these nematodes showed that *Helicotylenchus*, *Meloidogyne* and *Pratylenchus* were the major plant parasitic nematode genera most frequently recovered, most widely distributed and had the highest population densities compared to other genera. *Meloidogyne* and *Pratylenchus* were found in all three regions surveyed.

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