Plant Nematology in Ghana

Plant Nematology in Ghana

Edited by

Seloame Tatu Nyaku
and Francis Collison Brentu

Cambridge
Scholars
Publishing

Plant Nematology in Ghana

Edited by Seloame Tatu Nyaku and Francis Collison Brentu

This book first published 2022

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-7996-4
ISBN (13): 978-1-5275-7996-5

TABLE OF CONTENTS

SECTION 1:

NEMATODES OF TREE CROPS

CHAPTER 1

NEMATODES OF PARA RUBBER

FRANCIS COLLISON BRENTU[1]
AND SELOAME TATU NYAKU[2]

[1]Forest and Horticultural Crops Research Centre (FOHCREC), University of Ghana

[2]Department of Crop Science, College of Basic and Applied Sciences, University of Ghana, P.O. Box LG 44, Legon-Accra, Ghana

Introduction

Para rubber *Hevea brasiliensis* (Willd) Muell is a South American native plant and a member of the family Euphorbiaceae, which usually grows to a height of 45 meters. According to Raemaekrrs (2000), the natural habitat of the rubber tree is the forest of the Amazon River basin in Brazil. The trees have smooth bark and palmate compound leaves. These plants are monoecious with small flowers which are difficult to visualise. Upon ripening, the fruit capsule explodes, and seeds are released and dispersed from the tree. Para rubber is a perennial crop and starts yielding six to seven years after planting (Tweneboah 2000). Both Tweneboah (2000) and Raemaekrrs (2000), stated that in 1876, seeds of the Para rubber tree were smuggled out of Brazil and planted in green houses at Kew Gardens in Great Britain. The seedlings in the greenhouses were known as 'Wardian cases' and were taken to Ceylon, Singapore and the Royal Botanical Gardens at Penang in Malaysia. Kew Gardens were also the source of rubber in Africa (Liberia, Ghana, Congo, Brazzaville, Nigeria, Uganda, Cameroun and Cote d'Ivoire).

The majority of trees planted are usually bred for latex production. The tree trunk is generally straight, however heavy branching is also observed on this tree. The branching pattern shows variations, and the leading stem also can divide into other branches. The tree can be damaged by strong

winds (Lemmens *et al*. 1995). Clonal variation in wind resistance has been observed, depending on types of branching https://iproject.com.ng/agriculture/the-positive-impact-of-rubber-production-on-the-economic-development/index.html. Latex tapping from matured rubber trees can be initiated between the ages of seven to ten years after tree maturity https://iproject.com.ng/agriculture/the-positive-impact-of-rubber-production-on-the-economic-development/index.html. Rubber trees' life cyles are thirty to thirty-five years and can be used for latex production. The latex bearing plants can be found in various botanical families (Sapotaceae, Moraceae, Compositae, Apocynaceae, Asclepiadaceae and Euphorbiaceae). There are estimates of about eighteen thousand species of latex-producing plants, however, not all of these have been fully exploited.

In Asia, the average yield of rubber ranges from 1-1.5 tonnes/hectare/year. Common clones being used are **GT1, IRCA 41, IRCA 317, IRCA 230** and more. The **GT1** clone yields about 1.9 tonnes/hectare/year in the first five years. This rises to 2.1 tonnes/hectare (dry) base/year (Raemaekrrs 2000).

Rubber can be successfully cultivated in low humid or tropical conditions, roughly between 15˚C. N and 10˚C S, with comparatively little temperature variation. Planting above 400-500 m is discouraged because trees at high altitudes have restricted growth and low latex and timber production is observed. In regions with high rainfall, good soil drainage is needed. However, in certain regions where drought is severe, these trees can survive up to three months.

The mean annual temperature for rubber growth is 23-35°C and a mean annual rainfall of 1,500-3,000 mm. Para rubber can also tolerate waterlogging and wide pH ranges (4-8), however, growth is enhanced in acid soils.

Fig. 1.1. Rubber Tree (Photo credit George Nii Ankrah).

Para rubber production in Ghana

The cultivation of rubber started before World War II, but this did not have any economic impact. The Government of Ghana (GoG) embarked on the development of tree crops just after Ghana's independence of which rubber was a component. Between 1957 and 1968 the development of rubber was accelerated with Fire Stone Tyre Company of the USA spearheading the development. During this period, small holdings were also encouraged to develop their farms. Due to the economic downturn, the development of rubber was stagnated, and the smallholder farmers were abandoned (Tweneboah 2000).

However, rubber was introduced in Ghana as an ornamental tree in the Aburi Botanical Gardens in 1890. In 1930, the United African Company carried out a small-scale test in the Western Region. In 1957, the East Asiatic Company planted 923 hectares at Dixcove in the Western Region (Tweneboah 2000).

In late 1980, GoG initiated the Agricultural Diversification Programme and rubber was identified as one of the tree crops under the programme. This resulted in the launching of the Out Grower Project. Ghana now has a

Rubber Development Master Plan (MoFA 2007). In 1960, Dixcove Plantation was nationalised, and the Agriculture Development Company (ADC) was formed to manage the plantation. The ADC developed rubber on an industrial scale. The Agriculture Development Company was incorporated into State Farms Corporation (SFC). State Farms Corporation developed rubber in other parts of the SFC in Ghana (Tweneboah 2000).

Individuals and cooperatives were assisted to develop 3,500 hectares in 1961. Also, Fire Stone Tyre Company of the USA entered into a joint venture with GoG in 1968. The GoG used the plantations as equity, and it was termed Ghana Rubber Estates Limited (GREL). The joint venture was then abrogated in 1981. The farmers who were encouraged to plant rubber lost confidence in the industry because there was no outlet to sell their produce and the development of rubber in Ghana collapsed (Tweneboah 2000). The GREL was rehabilitated between 1988 and 1996 and a new processing factory was built as part of the agricultural diversification programme (MoFA 2007).

Ghana Rubber Estates Limited set up a purchasing unit in May 1992 to buy rubber regularly from farmers and this restored farmers' confidence in the industry. GREL was later privatised in 1996 with a 1,200-hectare plantation. Phases I and II of the Out Grower Project were then launched in 1995 and 2001 respectively in the Western Region. By 2005, 900 out-growers had been assisted to plant 4,055 hectares of rubber. In 2006, phase III of the Out Grower Project was launched in the Western and Central Regions of which 1,750 out growers were assisted to plant 7,000 hectares by 2010. The proposed phase IV took place in the last quarter of 2009 on a pilot basis.

Among the rubber-producing areas in Ghana is the FOHCREC, Kade which was established in 1957 by the University of Ghana with the full support and encouragement of the GoG. The Cocoa Marketing Board provided a foundation grant of £1 million. Out of this amount, £250,000 was spent on developing the centre and the remaining £750,000 was invested in the cultivation of crops such as citrus to provide funds for the maintenance of the centre. The area under investigation is about 2,700 acres.

Para rubber covers about 955 acres. The rubber plantation was established at the centre between 1957 and 1961. There are clonal lines of Para rubber at the centre, which represents about 50% of the rubber genetic material in the country. In 2018, the production and area harvested from rubber was 23,874 tonnes and 27,663 hectares respectively in Ghana. Additionally,

rubber yields in Ghana during this period were 8,630 kg/ha (FAOSTAT, 2019).

Limitations of Para rubber production in Ghana

Natural rubber as an agricultural commodity contributes to the foreign exchange earnings and socio-economic development of Ghana. However, the production of rubber is uncertain due to some constraints. The high cost of production makes the export potential very bleak. Natural rubber cultivation is faced with competition from the synthetic rubber industry in industrialised countries such as the United States of America (USA).

The synthetic industry claims not without justification that the synthetic product is of higher quality, cleaner, has greater elasticity and is more resistant to wear than natural rubber. Synthetic rubber has been produced in the USA which is 30% more resistant to wear than natural rubber in tyre treads (Bates 1957).

Despite the benefits that the country stands to gain from an efficient rubber industry in Ghana, the subject suffers from a dearth of information and studies. As Ahiepkor (1989) observes, research on rubber in Ghana lags behind the cultivation of the crop, and that is more reason why efforts should be intensified to help improve the cultivation of this important industrial crop. Opoku (1966) reveals that existing studies on rubber production tend to focus on the replanting or rehabilitating of old rubber trees and new planting programmes on virgin lands. Distribution of improved clones or seedlings without any consideration of the constraints of rubber production as well as the mechanism of response among the rubber producers are necessary for the success of those endeavours.

Rubber, which was one of the first commodities to be exported in 1904 as noted by Cuthbert (1911), has been characterised by fluctuations in productivity over the study period 1988-1995. Wood (1986) reported that among the factors affecting rubber productivity, clone type has been the most limiting factor. Similarly, Wycherley (1963) stated that soil constitutes the main aspect of the environment that greatly affect the growth and productivity of rubber trees.

Nematodes associated with Para rubber in Ghana

Although there are fungal, bacteria and suspected viral or phytoplasma induced diseases, no records of any economic loss due to nematodes

damage on Para rubber has been reported in the country. Other PPN such as *Criconemoides* spp., *Helicotylenchus* spp., *Hemicycliophora* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Rotylenchoides* spp., *Rotylenchulus* spp., *Scutellonema* spp., *Trichodorus* spp., *Tylenchulus* spp., *Tylenchorhynchus* spp. and *Xiphinema* spp. have been reported to be associated with Para rubber in Ghana (Addoh 1971). The survey was conducted at the FOHCREC, Kade, at the University of Ghana, to determine PPN associated with the crop. The centre owns over eighty acres of rubber plantation and about twenty different clones from all over the world.

Three different clones were selected for sampling (Table 1.1). Ten trees were randomly selected from each clone. The clones are GT1, IRCA41 and IRCA317. Nematodes are rarely distributed evenly in a field thus samples were collected from several locations within the field (Coyne *et al*. 2007). The systematic sampling pattern was used for both roots and soil sampling. Sampling was done randomly as it took into consideration the nature of the field and the nematodes' distribution.

Table 1.1. Description of rubber clones surveyed for PPN

Clones	Age (years)	Size (Acres)	Number of plants sampled
GT1	6	1	10
IRCA317	6	1	10
IRCA41	6	1	10

Data Source: Kingsley Mawuko Hiame (B.Sc. Dissertation, 2015).

Sampling results

The nematode population densities found in the rhizosphere of the three clones ranged from 0.0 to 46.9. Significant differences existed among the nematode populations in soil samples for the various rubber clones (Table 1.2). The GT1 clone had the highest nematode populations for all nematode species, except for *Cephalenchus* spp. The rubber clone (IRCA 317) had the least nematode populations for all the nematodes identified.

Table 1.2. Nematodes population density found in 100 g of soil in the three clones of Para rubber.

Rubber clones	*Helicotylenchus* spp.	*Scutellonema* spp.	*Meloidogyne* spp.	*Cacopaurus* spp.	*Cephalenchus* spp.
GT1	46.9a	14.7a	26.0a	23.8a	7.6a
IRCA 317	1.3b	0.0b	4.7b	0.6b	0.3b
IRCA 41	6.4b	7.6ab	15.7ab	4.2b	10.0a
LSD (5%)	18.06	8.9	17.6	11.9	6.9

NOTE: Means with the same letters in a column are not significantly different at ($P \leq 0.05$).
Data Source: Kingsley Mawuko Hiame *(B.Sc. Dissertation, 2015).*

Nematode population densities in the roots of the three clones ranged from 3.4 to 16.2 (Table 1.3). There were significant differences among the nematode populations in root samples of the rubber clones.

Table 1.3. Population densities of five PPN found in 100 g of fresh roots of the rubber clones.

Rubber clones	*Helicotylenchus* spp.	*Scutellonema* spp.	*Meloidogyne* spp.	*Cacopaurus* spp.	*Cephalenchus* spp.
GT1	8.3a	6.2a	10.4a	4.3a	16.2a
IRCA317	7.0a	5.3a	6.7ab	3.4a	9.7a
IRCA41	11.0a	11.0a	15.2a	13.6b	11.9a
LSD (5%)	6.6	6.5	7.5	6.0	10.1

NOTE: Means with the same letter in a column are not significantly different at ($P \leq 0.05$).
Data Source: Kingsley Mawuko Hiame *(B.Sc. Dissertation, 2015).*

The identification of the genera of PPN was based on the presence of the stylet, the position of the vulva, spicule, and their movement, length and shape. The PPN identified were *Helicotylenchus* spp., *Meloidogyne* spp., *Cacopaurus* spp., *Cephalenchus* spp. and *Scutellonema* spp.

The nematodes *Criconemoides* spp., *Helicotylenchus* spp., *Hemicycliophora* spp., *Meloidogyne* spp., *Pratylenchus* spp., *Rotylenchulus* spp., *Scutellonema* spp., *Trichodorus* spp., *Tylenchulus* spp., *Tylenchorhynchus* spp. and *Xiphinema* spp. have previously been found associated with Para rubber in Ghana (Addoh 1971). *Meloidogyne exigua* has been found in rubber plantations in Brazil (Duarte 2019). In this study, remote sensing technology

using water balance, precipitation, temperature and NDVI (Normalised Difference Vegetation Index) was used for determining *Meloidogyne exigua* infestation levels. Results revealed that the best months for nematode soil infestation analysis were December, January and February, while for root infection it was August.

The amount of damage these nematodes cause depends on a wide range of factors such as their population density, the virulence of the species or strain and the resistance or tolerance of the host plant. Other factors that contribute to a lesser extent include climate, water availability, soil conditions, soil fertility and the presence of other pests and diseases of Para rubber. Although we have some knowledge on the nematode-crop relationship and influencing factors such as water availability and nematode population density, much remains to be explored.

References

Addoh, P. G. 1971. "The distribution and economic importance of plant-parasitic nematodes in Ghana." *Ghana Journal of Agricultural Science* 4 (1): 21-32.

Agrios, G. N. 2005. "Plant pathology 5th Edition: Elsevier Academic Press." Burlington, Ma. USA: 79-103.

Ahiepkor, E.K.S. 1989. "Rubber", University of Ghana Agricultural Research Station, Kade-Combined Annual Reports.

Bates, W. N. 1957. "Mechanization of tropical crops." *Mechanization of tropical crops.*

Coyne, D. L. 2007. *Practical plant nematology: a field and laboratory guide*. IITA.

Cuthbert, C. 1911. *The African rubber industry and Funtumia Elastica ("kickxia")*. J. Bale Sons & Danielson, Limited.

Duarte, D. M., C. R. da Silva, E.M. Lemes, L. Coelho, and F. Rodrigues. 2019. "Analysis of infestation of nematode *Meloidogyne exigua* in a rubber tree plantation in the Triângulo Mineiro region." *Floresta e Ambiente* 26 (4).

Lemmens, R. H., M.J Soerianegara, and W. C. Wong. 1995. "Plant resources of South-East Asia. 5 (2): Timber trees: minor commercial timbers."

Opoku, A. A. 1966. "Rubber Production: History of developments in Ghana and the world." *The Ghana Farmer* 1 (1). 10-17.

Raemaekers, Romain H., (ed). 2000. *Crop production in tropical Africa*. Belgium: DGIC.

Statistics, F. A. O. 2019. “Food and Agriculture Organization of the United Nations.” Retrieved 14-06-20. http://www.fao.org/faostat/en/#data

Taylor, D. 1990. “Research on multipurpose tree species in Asia”. No. 634.98 R432r. Winrock International Institute for Agricultural Development.

Tweneboah, C. K. 2000. “Modern agriculture in the tropics.” *A textbook on Animal production.* Accra: Co-wood Publishers.

Wood, B. J. 1986. “A brief guide to oil palm science.” Incorporated Society of Planters.

Wycherley, P. R. 1962. “Variation in the performance of Hevea in Malaya.” Botanical Division, Rubber Research Institute of Malaya.

CHAPTER 2

NEMATODES OF OIL PALM

FRANCIS COLLISON BRENTU[1],
SELOAME TATU NYAKU[2],
AND ERIC WILLIAM CORNELIUS[2]

[1]Forest and Horticultural Crops Research Centre (FOHCREC), University of Ghana

[2]Department of Crop Science, College of Basic and Applied Sciences, University of Ghana, P.O. Box LG 44, Legon-Accra, Ghana

Introduction

Oil palm (*Elaeis guineensis* Jacq.) is a monocotyledon, which grows from the centre. This plant produces one single leaf at a time, which emerges from the apex, and the leaflets are usually folded against each other. The leaflets are opened to enable photosynthetic activities to occur in the leaf. The lifespan of a palm is about sixty-five years during which it can also reach heights of 20 meters (Hartley 1988). Oil palm production requires an ideal climate of at least 2,000 mm of evenly distributed rainfall per year. Oil palms are only able to establish themselves in the forest climate either on riverbanks or where an opening is created to allow sufficient sunlight.

Fig. 2.1. Oil palm plantation (Photo credit George Nii Ankrah).

The oil palm industry in Ghana

The oil palm industry today is characterised by a few larger-scale organised plantations which account for more than 90% of the industrial large-scale oil palm cultivation. There are also many scattered and unorganised smallholders with fewer than ten acres with little or no modern inputs which together contribute substantially to the crude palm oil market. Currently, the few large and medium scale plantations hold 50,000 hectares. It is estimated that the numerous small holders may hold about 50,000 hectares with a production of 3-5mt/ha compared to the average output of 15mt/ha in the larger establishments.

The oil palm industry in Ghana is presently characterised by three large-scale organised companies; The Ghana Oil Palm Development Corporation (GOPDC), Benso Oil Palm Plantation (BOPP) and the Twifo Oil Palm Plantation (TOPP). These three plantations account for more than 90% of the industrial large-scale oil palm cultivation in Ghana. Unilever Ghana Limited holds 58% and 40% respectively of the equity in BOPP and TOPP. GOPDC is 80% majority-owned by SiAT; a Belgium based agr-processing company. The Norwegian Oil Palm company limited (NORPALM)

is also an organised industrial plantation although on a smaller scale. Their levels of palm oil production in Ghana were 312,530 mt in 2018 (FAOSTAT 2019).

Due to its intrinsic qualities, palm oil produced from the crop is an important and versatile raw material for both food and non-food industries, which contributes to the economic development of the producing countries such as Ghana and also to the diets of millions of people around the world (Simeh *et al*. 2001). Oil palm is an important crop and has been used in various palm oil products in Ghana (Table 2.1).

Table 2.1. Food uses of palm oil products.

PRODUCT	DESCRIPTION
Cooking oil	An excellent general-purpose household cooking oil. Extremely stable to high temperatures during frying.
Industrial frying fat	For processing instant noodles, yam chips, French fries and doughnuts. Used extensively in fast food chains for fried chicken and snack foods.
Margarine	An ideal ingredient for the manufacture of margarine because of its wide range of solid fat content.
Shortenings	Palm oil-based shortenings are suitable for making loaves of bread, cakes, pastries, cream cakes and other bakery products.
Confectionery fats	Palm mid-fractions can replace cocoa butter in the confectionery industry and are well accepted today.
Ice cream	A common ingredient in the manufacture of ice cream, replacing the traditional milk fat.
Non-diary cream	A blend of palm oil and palm kernel is used to replace milk fat in non-diary cream or coffee-whiteners.

Table 2.2. Non-food uses of palm oil products.

PRODUCT	DESCRIPTION
Soaps	An excellent raw material in soap making with superior foaming power and colour, for example, Alata Samina.
Epoxidased palm oil	The quality of plastic is enhanced by epoxidase palm oil products (EPOP) in the manufacture of PVC jungle boots etc.
Palm-based oleochemicals	Palm oil and kernel oil are sources of oleochemical raw materials that can replace the traditional sources of tallow and coconut oil in the oleochemical industry.
Fatty acids	Specialised applications in the flavour and fragrance of industrial products and lubrication agents. Used in the manufacture of candles and cosmetics.
Alpha-sulfonated methyl esters (SMEs)	SMEs are excellent surfactants and have detergency properties comparable to those from petrochemical sources.
Palm oil-based diesel substitute	Palm diesel used as a diesel substitute has various advantages – reduced carbon particles in exhaust fumes and less smoke production. Apart from palm diesel, crude palm oil can be used directly as a fuel to run cars fitted with suitably modified (Elsbett) engines.
Fatty Alcohols	Palm-based fatty alcohols are expected to gain prominence in the manufacture of washing and cleaning products.
Glycerol	Glycerol is an important by-product of the palm-based oleochemical industry and is often used as a carrier for pharmaceutical products; as a humectant in cosmetics and as an ingredient in the production of emulsifiers.

Nematodes associated with oil palm in Ghana

Although there are fungal, bacterial, and suspected viral or Phytoplasma-induced diseases, no records of any economic loss due to nematode damage on oil palm has been reported in Ghana. Other PPN such as the *Meloidogyne* spp., *Helicotylenchus* spp., *Pratylenchus brachurus, Longidorus* spp., *Tylenchorhyncus* spp. and *Xiphinema* spp. have been reported on oil palm in Ghana (MoFA 2020).

Meloidogyne spp.

Root-knot nematodes occur throughout the world but are found more frequently and in greater numbers in areas with warm or hot climates and short or mild winters. They are also found in greenhouses everywhere when non-sterilised soil is used. They attack more than 2,000 species of plants, including almost all cultivated plants (Agrios, 2005).

Root-knot nematodes damage plants by devitalising root tips and either stopping their growth or causing the formation of swelling of the roots, which not only deprive plants of nutrients but also disfigure and reduce the market value of many root crops (Bird, 1974).

Pratylenchus spp.

Root-lesion nematodes of the genus *Pratylenchus* are recognised worldwide as one of the major constraints of a crop of primary economic importance. *Pratylenchus* spp. comprises around 70 nominal species of worldwide distribution which parasitise a wide variety of plants species. Members of this genus are called root-lesion nematodes because they produce lesions on feeder roots and occasionally on other underground plant parts as a result of their feeding. They are sometimes referred to as meadow nematodes due to their frequent occurrence in that environment.

Plants parasitic nematodes are generally extracted from the roots on which they feed (Agrios 2005). A few kinds of nematodes, however, attack above-ground plant parts, for example, chrysanthemum foliar nematode, grass seed gall nematode and the stem, leaf and bulb nematode; these nematodes can be isolated primarily from the plant parts they infect.

Sampling of nematodes

A survey was conducted at the Forest and Horticultural Crops Research Centre (FOHCREC), Kade. The three farms sampled were categorised into upland, middle and lowland slopes in addition to a nursery (Table 2.3). The upland farm (plot BS 9) had the Acrisols soil series characterised by a lot of gravels and stones, the middle slope (plot AS 10) was made up of the Lixisols soil series which had fine soil particles, and the lowland (plot BS 11) which is generally best suited for oil palm production, was made up of the Regosols soil series.

Table 2.3. Description of Oil palm plantations selected.

Farm number	Age (years)	Size (Hectares)	Number of plants sampled
Upper slope (BS 9)	15	24	100
Middle slope (AS 10)	17	24	150
Lower slope (BS 11)	11	24	200
Nursery	7 months	2	90

Data Source: Kwame Owusu-Sarpong (B.Sc. Dissertation, 2010).

Sampling pattern

Nematode samples were taken from the upland, middle slope and lowland areas of the farms as well as oil palm nursery sites at FOHCREC, Kade. The systematic sampling pattern was to take both root and soil samples. Soil samples were collected 30 cm deep from the rhizosphere of the oil palm trees using an earth chisel. Lateral roots were collected from the soil under the palm tree canopy using a cutlass and a spade. Soil and root samples were bulked to make a composite sample weighing 1-2 kilograms. The samples were mixed thoroughly, placed in clearly labelled polythene bags, and then kept in refrigeration at about 4˚C before nematode extraction.

Extraction of nematodes

The extraction tray method (modified Baermann's technique) was used. This technique involved the use of a plastic dish and a sieve with a diameter of 16.5 cm placed in this dish. The sieves were locally made by sectioning a plastic pipe of inner diameter 16 cm into rings measuring 2 cm in depth. The mesh of the sieve was made of mosquito nylon netting

which was glued to the ring of the plastic pipe. The sieves were slightly raised by 0.5 cm high supports known as plastic feet to prevent them from coming into direct contact with the dish. This ensured easy migration of the nematodes into the water in the dish (Coyne *et al*. 2007). Facial tissue paper covered the base of the sieve fully and was placed in the plastic plate and labelled.

Soil crumps were broken up and all stones and roots were removed from the composite sample. 100 g of soil was weighed and poured on the tissue paper in the sieve; water was added carefully into the dish making sure the water ran down the gap between the dish and the sieve. Water was added to each dish to wet but not cover the soil or root tissue, ensuring there was sufficient water, so it didn't dry out. The roots were also washed under tap water and then gently dabbed dry with tissue paper. They were chopped finely with a knife, blended for five seconds and then placed on tissue paper in the sieve as was done for all the soil samples.

The procedures for soil and root samples were repeated until fourteen set-ups were obtained. The extracts were incubated at the laboratory at room temperature for forty-eight hours after which the sieve was removed to dispose of the soil and roots. The suspension was poured into separate labelled plastic bottles then a wash bottle was used to thoroughly rinse the plastic dish into the bottles. The suspension was put on a cool plate to allow the nematodes to settle for at least twenty minutes before counting. If counting was not going to be done immediately, the suspension was refrigerated at a temperature of 4°C before the nematode counting.

Identification and counting of nematodes

The volume of water in the bottle was reduced to 25 ml by using a water hose to siphon off excess water. The suspension was stirred to obtain a homogenous suspension. An aliquot of 2 ml was pipetted and placed on a counting dish and observed under a compound microscope. Identification of the various genera of nematodes was accomplished based on the presence of the stylet, the presence and position of the vulva as well as the spicule, their movement, length and shape of the tails (Dropkin 1989).

A microscope magnification of x100 was used to check the morphology of the nematodes then a magnification of x40 was used for counting them. Counting of the nematodes was done systematically following the gridlines

on the counting dish. A tally counter was used to count the different nematodes present. The counted aliquot was returned to the suspension after counting and the procedure was repeated three times using three aliquots per sample.

The nematode population density was calculated by multiplying the mean nematode count by the total volume of the suspension (25 ml); the value obtained was the number of nematodes present in the 100 g of soil and 5 g of the roots weighed.

The value obtained per 5 g of roots after the calculation was converted to the number of nematodes per 100 g of roots. This was done by dividing 100 g by 5 g then the result multiplied by nematodes counted in the 5 g of roots to obtain the nematodes' population density per 100 g of roots. Moreover, nematode populations in roots and soil samples at each farm were compared and analysed using the T-test calculation unpaired sample.

Sampling results

The populations of *Helicotylenchus multicinctus* in soil and root samples from oil palm plantation at FOHCREC, Kade showed varying population numbers (Table 2.4).

Table 2.4. *H. multicinctus* population densities per 100 g soil and 100 g fresh roots.

Plantation	*H. multicinctus* (soil)	*H. multicinctus* (roots)
Bs 9 (Upper slope)	0	0
As 10 (Middle slope)	0	0
Bs 11 (Lower slope)	0	160
Nursery	0	340
Mean	0	125

Data Source: Kwame Owusu-Sarpong (B.Sc. Dissertation, 2010).

Helicotylenchus multicinctus population densities in root samples ranged from zero to 125 per 100 g of fresh roots, but none were found in the soil samples (Table 2.4). However, values obtained for *H. multicinctus* were not statistically significant. The population densities of *Meloidogyne* spp. found in soil and root samples ranged from zero to ninety-two in oil palm plantations at FOHCREC, but none were identified in the root samples (Table 2.5). The highest population densities of *Meloidogyne* spp. were

obtained in the rhizosphere of the oil palm nursery, but values obtained were not significantly different among the plantations.

Table 2.5. *Meloidogyne* spp. population densities per 100 g soil and 100 g fresh roots

Plantation	*Meloidogyne* spp. (soil)	*Meloidogyne* spp. (roots)
Bs 9 (Upper slope)	0	0
As 10 (Middle slope)	0	0
Bs 11 (Lower slope)	25	0
Nursery	92	0
Mean	29	0

Data Source: Kwame Owusu-Sarpong (B.Sc. Dissertation, 2010).

Pratylenchus coffeae population densities obtained from soil and root samples ranged from forty-one to 150 per 100 g of soil, and zero to 1,210 per 100 g of roots respectively (Table 2.6). The *P.coffeae* population densities in root samples were more than those in the soil samples.

The three different PPN found to be associated with oil palm at FOHCREC, Kade were *Helicotylenchus multicinctus, Meloidogyne* spp. and *Pratylenchus coffeae*. *Pratylenchus* spp. was the most frequently encountered nematode in the study, appearing in very high populations and all the soil and root samples. *Meloidogyne* spp. was the least encountered nematode and appeared in only soil samples with most of them being the second juvenile stage (J2).

Table 2.6. *Pratylenchus coffeae* population densities per 100 g soil and 100 g fresh roots.

Plantations	*P. coffeae* (soil)	*P. coffeae* (roots)
Bs 9 (Upper slope)	75	0
As 10 (Middle slope)	41	1500
Bs 11 (Lower slope)	150	2000
Nursery	83	1340
Mean	87	1210

Data Source: Kwame Owusu-Sarpong (B.Sc. Dissertation, 2010).

In this study, the nematode population densities obtained from root samples in all the farms were comparatively more than those obtained from soil samples. In farm BS 11 (lowland plantation) and the nursery site,

nematode population densities were higher than those identified in the other farms. This may be due to the conducive edaphic conditions in the lowland areas. The soil in the lowland plantations was the Rogosols' soil series, which hold adequate moisture and have a good drainage system. These soils are dark brown, with high organic matter. The nursery site also has a constant supply of water through a drip irrigation system. Nematodes' species increase their populations during the growing wet season and their numbers reduce during the off (dry) season (Coyne *et al.* 2007). This explains why their population densities were higher in the BS 11 and nursery farms. *Helicotylenchus* and *Meloidogyne* spp. were absent in the upland and middle slopes. The soils of upper and middle slopes of farms sampled consist of the Acrisol and Lixisol series respectively. These soil series are mostly clayey, dry and reddish, resulting in low nematode populations in these regions.

In Trinidad, nematode infection resulted in a 35% loss of young palm trees. A plantation had also lost about 80% of its oil palm trees to nematodes. In Venezuela, over ten years about 35% of deaths of oil palm trees were experienced because of red ring disease. In other areas e.g., Grenada, about 22.3% of oil palms were found to be infected. Of those infected, 92% had palm weevils and it was estimated that 72% of those weevils were carrying the *B. cocophilus* (Esser & Meredith 1987). Considering that more than eight million acres of oil palms are grown, red ring nematodes are one of the most significant pests in the tropics.

The level of damage from these nematodes relates to their population densities, virulence and plant tolerance or resistance levels to the nematodes. Other less contributory factors include climate, water availability, soil conditions and soil fertility.

References

Agrios, G. N. 2005. "Plant pathology 5th Edition: Elsevier Academic Press." Burlington, Ma. USA: 79-103.

Bird, Alan F. 1974. "Plant response to root-knot nematode." *Annual Review of Phytopathology* 12 (1): 69-85.

Coyne, D. L. 2007. *Practical plant nematology: a field and laboratory guide*. IITA.

Dropkin, V. H. 1980. "Introduction to plant nematology John Wiley & Sons." EEUU. 216.

Esser, R. P., and Meredith, J. A. 1987. “Red ring nematode (Nematology circular No. 141).” Gainesville: Florida Department of Agriculture and Consumer Services, Division of Plant Industry.

La Anyane, S. 1961. *The Oil-palm Belt of Ghana* (1). Division of Agricultural Economics, Ministry of Agriculture.

Gyasi, E. A. 1992. “Emergence of a new oil palm belt in Ghana.” *Tijdschrift voor economische en sociale geografie* 83 (1): 39-49

Hartley, C. W. S. 1988. “The oil palm” Longman Group.

Owusu-Sarpong, K. 2010. “Plant-parasitic nematodes associated with oil palm at the University of Ghana, Forest and Horticultural Crops Research Centre, Kade.” *BSc Dissertation*. Department of Crop Science, University of Ghana, Legon, GH.

Simeh, Arif & Ahmad, T.M.A.T. 2001. “The case study on the Malaysian palm oil.” *Regional Workshop on commodity export diversification and poverty reduction in South and South-East Asia, Bangkok*: 3-5.

Food and Agriculture Organization of the United Nations. Retrieved 14/06/2020. http://www.fao.org/faostat/en/#data

CHAPTER 3

NEMATODES OF COCOA

FRANCIS COLLISON BRENTU[1]
AND SELOAME TATU NYAKU[2]

[1]Forest and Horticultural Crops Research Centre (FOHCREC), University of Ghana

[2]Department of Crop Science, College of Basic and Applied Sciences, University of Ghana, P.O. Box LG 44, Legon-Accra, Ghana

Introduction

Cocoa (*Theobroma cacao* L.) is a small evergreen tree (4-8 m) that is native to the tropical forest regions of South America (McNeil 2006). There are three main cultivars of cocoa, namely, Criollo, Forastero and Trinitario (hybrid between Criollo and Forastero). Amelonado is another forest type collected from the Amazon Forest with a melon-shaped pod. Cocoa is mostly propagated by seed but sometimes with the bud for experimental purposes. Cocoa requires a minimum of 90-100 mm rainfall per month with 1,500-2,000 mm precipitation; pH requirement is between 4.5 and 8.0 but it also does well on neutral soils. Cocoa can be planted 2.5-3.0 m apart within and between rows.

Fig. 3.1. A cocoa tree with pods (Photo credit George Nii Ankrah).

Origin, distribution and spread of cocoa

Cocoa originated from the Amazon in South America. The cultivation and value of cocoa spread throughout central and eastern Amazon and northwards to Central America. The native Americans used cocoa beans to prepare chocolate drinks and they were used as a form of currency for trading. According to the best estimates of archaeological dating, it is believed that the Olmecs (an ancient people of America) were the first people to cultivate cocoa around 1000 BCE. In 1521 when Central America was conquered, Hernan Cortez and his soldiers took a small cargo of cocoa beans to Spain together with utensils for making chocolate drinks.

In 1580, the chocolate drink became popular and cocoa beans were shipped to Spain regularly from Central America. Cocoa became popular and quickly spread to Italy in 1606, France in 1615, Germany in 1641 and Great Britain in 1657. The Spanish were the first to start large scale cultivation in the 16th century in central America. The cocoa plant then spread to Britain, the French and the Dutch West Indies (Jamaica, Martinique and Surinam) in the 17th century and to Brazil in the 18th century.

Cocoa was then taken from Brazil to Sao Tome and Fernando Po (now part of Equatorial Guinea) in 1840. Cocoa spread from there to other parts of West Africa particularly; the Gold Coast (now Ghana), the Ivory Coast and Nigeria. Records indicate that the Dutch missionaries in 1815 and the Basel missionaries in 1843 first brought cocoa to the Gold Coast. Tetteh Quarshie travelled to Fernando Po, and he worked as a blacksmith and upon his return to the Gold Coast, he brought Amelonado cocoa pods and established a cocoa farm at Akuapem Mampong in the eastern region. Farmers bought cocoa pods from his farm and cocoa spread to different parts of the eastern region.

Sir William Griffiths, the Governor of the Gold Coast in 1886 ordered cocoa pods from Sao Tome. Cocoa nurseries were raised at the Aburi Botanical Gardens and distributed to farmers. To enhance the cocoa industry in Ghana, the government established the Ghana Cocoa Board as the major government agency responsible for the development of the industry. Presently there are six regions in Ghana where cocoa is grown. These regions are Ashanti, Western (now Western and Western North), Brong Ahafo, Eastern, Volta (now Volta and Oti) and Central with the Western North region being the largest producer and Volta been the least (Sosamma *et al.* 2009).

Papua New Guinea, Brazil, Ecuador and Colombia are other major cocoa producers contributing to about 25% of world production. The United States and most European countries such as Switzerland, Belgium, Germany, Netherlands and the United Kingdom import most of the cocoa beans and process them into various products such as chocolate, butter and cocoa powder.

Cocoa was first exported from the Gold Coast in 1891. Since then, cocoa has been the main foreign-exchange agricultural commodity in Ghana, and a major contributor to the economy (Opoku *et al*. 2006). Between 1910 and 1977, Ghana was the leading producer of cocoa worldwide with about