Soil nematode population studies of some selected plantation crops and uncultivated coastal thicket

C. K. A. MARSHALL & Y. OPOKU-ASIAMA
Department of Crop Science, University of Cape Coast, Cape Coast, Ghana

ABSTRACT

The study was conducted on citrus, plantain and pineapple plantations on the Teaching and Research Farm of the School of Agriculture, University of Cape Coast. The survey also covered undisturbed coastal thicket near the site of the study. The aim of the survey was to identify types and population levels of plant parasitic nematodes in soils of the different plantation crops and to find out whether the populations and nematode species differed from those in soils of undisturbed vegetation. The investigations were carried out from April to July 1993. Nematodes were extracted from 100 ml soil samples by an improvised Baerman's Tray technique and the mean recorded. Nematode counts were determined from 1ml aliquots repeated tree times. Three genera, namely *Rotylenchulus, Meloidogyne* and *Pratylenchus* as endo-parasites, *Tylenchus* (semi-endoparasitic) and eight ecto-parasitics forms which included *Xiphimena*, a known virus vector, were identified. *Meloidogyne, Pratylenchus, Helicotylenchus* and *Tylenchus* occurred in all the plots studied. *Hemicyclophora* and *Xiphimena* were the least genera and occurred in low numbers. Plantain supported the greatest number of genera and also the highest nematode populations. There were positive correlations between crop types, soil *p*H, soil moisture and nematode numbers. Similarly, significant differences were observed between means of initial nematodes numbers at the beginning and end of the season.

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Introduction

Permanent cropping, if not well managed, leads to pest population build-up and associated pest problems. According to Thorne (1961), nematodes constitute one of the most important groups of organisms, which inhabit the soil around the roots of plants, and adversely affect the growth and production of crops. Good *et al.* (1973) have observed that the populations of nematodes were affected by host plants. For example, *Pratylenhus* spp. will build up on corn, a non host for soybean cyst nematode, *Heterodera* sp., if corn is planted too often. When pea and mustard were either sown alone or together in alternate rows, after four months, the populations of *Rotylenchulus reniformis* and *Tylechorhynchus* sp. declined significantly. In other words, the vegetation of an area has an influence on the nematode population. A survey of pineapple growing areas of Hluhluwe in Natal revealed that land not previously cultivated could be infested with damaging levels of plant parasitic nematodes. As such, nematode damage during the first crop cycle on new land will depend on the composition of the natural vegetations (Anon., 1991). A survey on pineapple farms indicted *Helicotylenchus dishystera, Scutelloma brachyurum, Pratylenchus coffeae, Criconemella oranata* and *C. xenoplax* as most serious in pineapple (Rama & Dasgupta,1987).

Studies on plantain crops by Queneherve (1989), and Volker & Gamboa (1991) identified *Radopholus similes, Pratylenchus coffeae,* and *P. brachyrus* as most damaging to plantain. *Helicotylenchus multicintus* and *H. dishystera* have also been found to damage plantain. Roman (1989) reported *Helicotylenchus incognita* and *Rotylenchus reniformis* on plantain. On citrus, Verma (1967) noted *Tylenchorynchus* sp., *Tylenchus, Helicotylenchus, Hoplolaimus* and *Longidorus* as destructive.

The cultivation of plantation crops such as pineapple, plantain, and citrus has been on the increase in Ghana since the start of the export drive for non-traditional crops. The aim of the survey was to find out types and population of nematodes occurring in the plantations of pineapple, plantain and citrus in comparison to those soils under adjacent undisturbed vegetation at the Teaching and Research Farm of the School of Agriculture, University of Cape Coast, and how the populations vary with the seasons when influenced by some soil factors.

Materials and methods

The survey was carried out at the start and end of the main cropping season at the Teaching and Research Farm of University of Cape Coast. The University farm site has climax vegetation described as coastal ticket with a bimodal rainfall pattern. The major season usually starts from April to July, and the minor season usually occurs between September and November. In between the two peaks is a shot dry but cool period in August. The soils have been classified under the Edina-Benya-Atabadzi-Udu compound association (Asamoa, 1977). A survey was conducted in a 12-year old 1-ha citrus orchard; plantain plantation (0.2 ha) and from a land uncultivated for over 100 years

Soil sampling at the bases of the various plants was done based on a systematic pattern (zig-zag) adopted by Barker (1985), Roman (1986) and Wallace (1973), using a 5-cm diameter soil auger. Under plantain, soil samples were taken at about 0.5 m from the pseudostem (Roman, 1986). Under citrus, soil samples were taken from the drip line (Barker, 1985), and soil samples from the pineapple plantation were taken in between twin rows, as these loci were noted to have maximum fibrous root growth to a depth of 20-30 cm (Wallace, 1973). Final field soil samples consisted of 1.5 kg, each made up of a composite of 30 sub-samples. These were placed in labelled polythene bags secured with cords.

An improvised Baerman's tray technique was used for nematode extraction. The technique consisted of a plastic sieve lined with a double sheet tissue paper. Three replicates of 100-ml soil samples were set up and nematodes extracted

on the third day. Extracted nematodes were fixed to precipitate proteins and preserve specimens in life appearance. Fixative used was FA:10 as recommended by the Commonwealth Institute of Parasitology, Plant Nematode Identification, and S'Jacob & Bezooijen (1973). Nematode counts were made from three 1-ml aliquots in a counting dish under a stereoscopic microscope. Nematode genera identification was done using key and illustration by Thorne (1961) and Dropkin (1989).

Other parameters considered from the same soil were moisture and soil *p*H (water). Soil moisture was determined by gravimetric method designed by Gardner (1965). Soil *p*H values were assessed using a glass electrode *p*H meter (Peech, 1965). Statistical analyses used included population frequency distribution for nematode genera, t-test comparison of nematode population at start and end of season, and Pearson protect moment correlation between nematodes count, time of sampling, crop type, soil moisture and soil *p*H.

Results

Plant parasitic nematode genera

The results of plant-parasitic nematode genera identified under the three plantation crops and under the undisturbed coastal thicket are presented in Table 1. In all, total of 12 plant-parasitic nematode genera were identified. These were mostly in the juvenile stages. Four genera, namely *Rotylenchus, Rotylenchulus, Meloidogyne,* and *Pratylenchus* were endo-parasites. Ecto-parasites were *Xiphimena,* a virus vector, *Hemicyliophora, Tylenchorynchus, Rotylenchus, Helicotylenchus, Tylenchus, Aphelenchus* and *Paratylenchus*.

Tylenchorynchus, Pratylenchus, Helicotylenchus, and *Tylenchus* were found in all plots. The least frequently occurring genera were *Hemicyclophora* and *Xiphimen*. Soils under plantain were found to support the greatest number of genera.

Nematode population as affected by crop type

Of the four endo-parasites identified, *Tylenchulus* was found only under plantain and citrus. Three ecto-parasites found under pineapple were *Helicotylenchus, Tylenchus* and *Paratylenchus.* Apart from having the highest nematode genera, plantain was also found to support the greatest total population. The highest

TABLE 1

Plant-parasitic Nematode Genera Identified Under Some Plantation Crops at UCC Farm in 1993

Nematode genera	*Undisturbed vegetation*	*Plantain*	*Pineapple*	*Citrus*	*Frequency*
Hemicyliophora	+	-	-	-	1
*Rotylenchulus***	-	+	+	-	2
Tylenchorynchus	+	+	-	+	3
*Meloidogyne***	+	+	+	+	4
*Pratylenchus***	+	+	+	+	4
Rotylenchus	+	+	-	+	3
Helicotylenchus	+	+	+	+	4
Tylenchus,	+	+	+	+	4
Aphelenchus	+	+	-	-	2
*Tylenchulus****	-	+	-	-	1
Paratylenchus	+	+	+	-	3
Xiphimena,	+	-	-	+	2

(***) Endo-parasites (+) Present (-) Absent

population of any single genus recorded under the crops studied was *Rotylenchulus* in plantain at a level of 347 nematodes per 100 ml of soil (Table 2).

Meloidogyne, one of the most widely studied genuses, was found to occur in greater numbers under citrus. Highest levels of *Pratylenchus* and *Helicotylenchus* were found in pineapple at levels of 30 and 24 per 100 ml of soil, respectively. The undisturbed vegetation supported the least population of nematodes with the predominant genera being *Meloidogyne* and *Rotylenchulus*.

Time of sampling and nematode population

Paired samples t-test was applied to compare the mean of nematodes encountered at the start and end of season. These two periods corresponded with the time of planting (mid-April) and milk-dough stage of maize (end of June), planted on other fields on the University Research and Teaching Farm during the 1992 main cropping season. It was noted that nematode populations at the start of season (mid-April) were higher and statistically significant than at the end of June (Fig. 1) (Table 3). As shown in Table 2, nematode populations under the various crops for both start of season and end of June were plantain (974,599), pineapple (668,412), citrus (713,523) and undisturbed vegetation [un-veg. (144, 70)].

Relationship between nematode count, time of sampling, crop type, soil moisture and soil pH

Table 4 shows the relationship between time of sampling, crop type, soil moisture and soil *p*H and nematode count. The relationship was determined using Pearson-product moment correlation coefficients. There was a medium but non-significant association between time for sampling and nematode count where r = -0.4. There were, however, strong and significant relationships between nematode count and the following: crop type (r = -0.78), soil *p*H (r = 0.71)

TABLE 2

Population of Plant-parasitic Nematodes Found Under Some Plantation Crops at UCC Farm (1993 Main Season)

Nematode genera	*Plantain*		*Pineapple*		*Citrus*		*Undisturbed vegetation*	
	Start	*End*	*Start*	*End*	*Start*	*End*	*Start*	*End*
Hemicyliophora	-	-	-	-	-	-	6	-
Rotylenchulus***	347	100	54	44	-	-	-	-
Tylenchorynchus	45	31	-	-	23	9	21	10
*Meloidogyyne****	51	42	76	48	98	79	36	11
*Pratylenchus****	90	63	210	124	55	86	11	8
Rotylenchus	207	196	-	-	149	99	24	12
Helicotylenchus	45	29	141	97	109	73	19	7
Tylenchus,	96	67	138	81	92	54	19	13
Aphelenchus	24	10	-	-	-	-	6	7
*Tylenchulus****	69	53	-	-	182	123	-	-
Paratylenchus	-	8	49	18	-	-	2	-
Xiphimena	-	-	-	-	6	-	-	2
Total (gt 4104)	974	599	668	412	714	523	144	70
Mean	786.5	540	618	107				
SE	29	16	21	13	19	14	3	5

(***) Endo-parasites (-) Nil (gt = grant total) Each value is the mean of three aliquots.

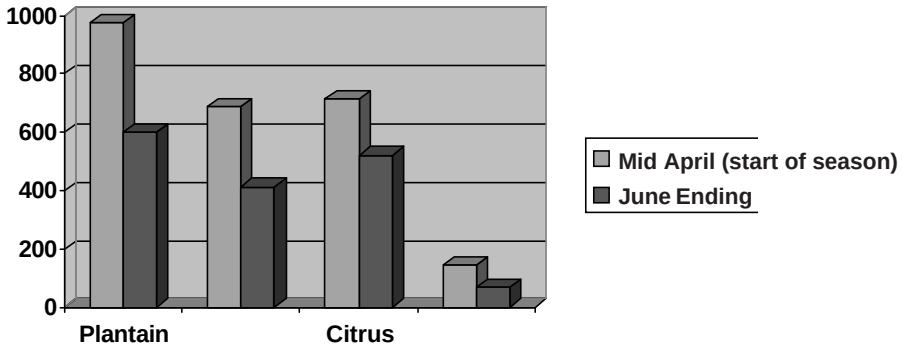

Fig. 1. Effect of season of sampling on nematode population
Means (each crop) followed by different letters are significantly different (P = 0.05), by t-test.

TABLE 3

Soil Moisture and Soil p*H Under Some Plantation Crops During Time of Nematode Sampling at UCC Farm (1992 Main Season)*

Variable	*Plantain*		*Pineapple*		*Citrus*		*Undisturbed vegetation*	
	Start	*End*	*Start*	*End*	*Start*	*End*	*Start*	*End*
Soil moisture (%)	14	6.7	10.7	5	12.6	6	7	4
soil *p*H	7	7.1	6.2	6.6	5	5.3	4.2	4.4

Each value is the mean of three aliquots.

TABLE 4

Pearson Product Moment Correlation Between Time of Sampling, Crop Type, Soil Moisture and Soil p*H and Nematode Count*

Variable	*Nematode count*	*Crop type*	*Soil* p*H*	*Time of sampling*	*Percent soil moisture*
Nematode count	-				
Crop type	-0.78*	-			
Soil *p*H	0.71*	0.98**	-		
Time of sampling	-0.40	0.00	0.14	-	
Percent soil moisture	0.83**	-0.42	0.30	0.82*	-

* Significant at P = 0.05. ** Significant at P = 0.01.

and soil moisture (r = 0.83).

Soil moisture at time of sampling

Initial percent moisture levels in the various plots were plantain (14.03), citrus (12.60), pineapple (10.76) and undisturbed vegetation (7.37). Percent moisture content of soils at the time of sampling toward the end of season was almost one half the values obtained at the start of season (Table 2). As can be seen under plantain, total nematode population at 14 per cent moisture content was 974 as against 599 at 6.73 per cent.

Similar trends were noted for the other plots. Soil *p*H change for the two sampling periods was less apparent on per plot basis as shown in Table 2. However, on per plot basis, nematode population appeared to decrease with decreasing soil *p*H. This observation was confirmed by positive correlation between soil *p*H and nematode population with $r = 0.83$ (Table 4).

Discussion

The range of genera of plant-parasitic nematodes found under plantain, pineapple, citrus and undisturbed vegetation were quite similar to those reported by Asare-Nyarko (1971) in a survey conducted on sugar cane estate at Komenda, a few kilometers from Cape Coast and under similar climatic condition. The only genera, which did not occur in this present survey were *Longidorella and Longidorous*.

The most important genera of plant-parasitic nematode under plantain were *Rotylenchulus* and *Rotylenchus,* which agreed with the findings of Roman (1986), Volkers & Gamboa (1991) and Quencherve (1989). Another genera, *Pratylenchus* sp. and *Rotylenchus* were described by the authors to be harmful species in plantain production. The occurrence of *Tylenchus,* sp. in the soils around roots of plantain supported the finding of Hemeng (1991). Paracer *et al*. (1967) reported *Tylenchus* sp. is in a group of ecto-parasites which generally causes slight injuries to their host plants. However, the relatively high population of *Tylenchus* spp. observed with plantain suggests that plantain is a good host and the species may be pathogenic to plantain. The presence of these parasitic genera in the soil of plantain farms may cause yield decline in plantain production.

Under pineapple, *Pratylenchus, Helicotylenchus, Rotylenchulus* and *Tylenchus* were found to be the most dominant genera. Species of *Pratylenchus* and *Helicotylenchus* have been described by Rama & Dasgupta (1987) to be among the most serious pests of pineapple. Though population of *Rotylenchulus* and *Meloidogyne* were not very high in the present study, population is expected to build up with time as was indicated by Caswell *et al.* (1990).

Rotylenchulus and *Tylenchulus* were the dominant genera found under citrus. *Meloidogyyne, Pratylenchus* and *Helicotylenchus* were relatively abundant. Most of these genera have been described as the main parasitic nematodes of citrus, especially species of *Tylenchulus.* In Ghana, *Rotylenchulus* has been definitely identified as a semi-endoparasite attacking and causing decline in citrus trees with *Helicotylenchus* (Cohn, 1972).

The wide range of all the important genera such as *Meloidogyme, Pratylenchus, Helicotylenchus* and *Xiphimena,* well represented in the undisturbed vegetation, suggests that the nematode already existed before the citrus and other crops were cultivated. Subsequent population build up of any genera over a time could be a function of crop varieties, soil type and other agronomic practices.

The fewer genera and lower nematode populations under pineapple could be attributed partly to the soil type. The pineapple plot was established on well-drained upper slopes of Atabaszi soil series. This series was characterized by low levels of organic matter associated with low levels of nutrients as described by Asamoa (1973). As stated by Wallace (1973), plants and nematodes have similar requirement of water. Since availability of plant nutrients to crops and mobility of nematodes is dependent on soil moisture, any factor that could lead to moisture loss from the soil is likely to adversely affect nematode population.

The relatively grater numbers of *Paratylenchus* found only under pineapple could be explained on the basis that *Paratylenchus* spp. have been reported to be most abundant in the summit and upper slopes of a toposequence (Dropkin, 1989). Plantain and citrus were planted in Udu and Benya soil series, respectively. These soil series had a greater depth of the B-horizon (second soil layer) along the soil profile, which

was higher in organic matter and cation exchange capacity than the pineapple plot. These characteristics couple with higher moisture content of these soils could have been the result of greater numbers of nematodes as found under citrus and plantain.

Secondly, plantain and citrus had large and more extensive root systems than pineapple. As a result, the chances of roots getting into closer vicinity of nematodes were greater in these crops than in pineapple. In addition, the citrus plantation had also been in existence for the past 12 years, and this could have led to population build-up over the years. The extensive root system could be due to compensatory growth process by host crop in abundance of organic matter to minimize nematode damage. On plots where *Xiphimena* was found, the genus was in very low numbers. This could be attributed to the fact that *Xiphimena* reproduces once yearly with fewer eggs as against *Meloidogyne,* which may develop into egg laying females in about 21 days and could lay as much as 2900 eggs (Barker & Nusbaumm, 1971; Dropkin, 1989), producing many generations in a year. Also, the soil processing prior to extraction could be a contributing factor. As stated by Asare-Nyarko (1971), *Xiphimena* spp. are large nematodes and easily killed by soil disturbance.

During the survey period, significant numbers of nematodes were found at the beginning of the season than at the end. This observation could be attributed to the amount of soil moisture available. As stated by Wallace (1973), in unsaturated soil, moist large pores which contain nematodes are partly filled with water which is favorable for nematode mobility. According to Simons (1973), the movement and other activities of nematodes are directly related to moisture quantity. High nematode populations found in high moisture levels, following period of drought (as in the case of this study), may be attributed to hatching of nematode eggs.

Mukthar *et al.* (1989) and Thomas (1978) found least numbers at pre-plant soil samples and greater numbers at pre-harvest. According to Ferris & Bernard (1971), ecto-parasitic species tended to increase in total numbers throughout a growing season. However, the observed trend in this study could be attributed to an unexpected and prolonged dry period during the major season of 1993 just after the season had begun. As reported by Thomas (1978), very dry periods caused a decrease in numbers of most nematodes. Siddique (1971) also observed that decline in nematode numbers during the dry period could either be due to desiccation or migration in the soil.

The variation in percentage soil moisture contents observed under plantain, citrus, pineapple and undisturbed vegetation (Table 2) could be attributed to differences in soil characteristics and topography. Plantain plot occupied the lowest section of the toposequence. Next up the sequence was Benya series in which citrus was growing. Pineapple plot was in Atabaszi series, which occupied the upper middle slopes. According to Wallace (1973), run-off on sloping land affected the moisture content of the sol. Even though the undisturbed vegetation was also on the same series as pineapple, the further reduced moisture value could be due to the dense canopy of the thicket and thick layer of fallen foliage cover over the soil. Since rainfall during the periods was inadequate, the fallen foliage layer could have absorbed any little moisture before it reached the soil surface.

The *p*H value observed was within the range of most agricultural soils. The *p*H of 7 recorded under plantain, which occupied the lowest level along the toposequence, and a lower value of 5.6 under pineapple on the middle slope were in agreement with the finding by Wallace (1973). He reported that water collecting at the foot of slopes may contain bases from higher ground and so soils on level ground tend to be less acidic.

The relatively more acidic soils under undisturbed vegetation could have been due to organic acids resulting from the decomposition of abundant organic matter over the years, as

noted by William & Fisher (1987). There was no obvious effect of *p*H on nematode population under each crop during the study. As noted by Sayre (1971), studies on the ecology of nematode revealed that *p*H has little influence on nematodes. However, among the various crops, it was observed that nematode populations increased with increasing soils *p*H, as depicted by observed correlation results.

Conclusion

The survey revealed that the soils studied under plantain, pineapple, citrus and undisturbed vegetation at the Teaching and Research Farm of the School of Agriculture contained pathogenic plant-parasitic nematode genera. It was evident that crop type significantly influenced the population dynamics of plant parasitic nematodes. Further, it was noted that nematode genera were fairly distributed in the different soil series. *Meloidogyyne, Pratylenchus, Rotylenchus, Helicotylenchus, Aphelenchus* and *Tylenchus* were the most dominant genera.

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