Journal of Soil Science and Environmental Management Vol. 4(1), pp.6-10, January 2013
Available online at http://www.academicjournals.org/JSSEM
DOI: 10.5897/JSSEM12.068
ISSN 2141-2391 ©2013 Academic Journals

Full Length Research Paper

Nematode pests of plantain: A case study of Ashanti and Brong Ahafo regions of Ghana

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Accepted 11 December, 2012

A survey of plantain farms was conducted in April 2012 at four locations in two districts of Ghana. The purpose was to identify plant parasitic nematodes (PPN) associated with plantain production in Ghana. The locations were Adomakokrom and Kenyasi in the Brong Ahafo, Adanwomase and Mpobi in the Ashanti region. Demographic and sociological data of farmers, plantain root lesion scores, PPN populations per 200 cm^3 soil and 5 g plantain roots were analyzed. Nematode damage to root at Adomakokrom, Adanwomase, Mpobi and Kenyasi were 50, 75, 75 and 50%, respectively. Five nematode species were recovered from the rhizosphere of plantain. The nematodes were in the order of importance; *Pratylenchus coffeae, Meloidogyne* spp., *Rotylenchulus reniformis, Radopholus similis* and *Helicotylenchus multicintus*. High populations of *P. coffeae* (803/200 cm^3), *H. multicintus* (292/200 cm^3) and *R. reniformis* (343/200 cm^3) were extracted from soil samples at Adomakokrom, Adanwomase and Adanwomase respectively. Four parasitic nematodes; *Meloidogyne* spp., *P. coffeae*, *R. reniformis* and *R. similis* were extracted from plantain roots. Root populations were higher compared with soil samples. For sustainable plantain production in Ghana, an efficient management option must be devised.

Key words: Ghana, integrated pest management, *Musa* spp., plant parasitic nematodes.

INTRODUCTION

Ghana has an agrarian economy driven by agricultural productivity and production. Plantains and bananas (*Musa* spp.) have been earmarked as central to the government's quest for the attainment of a middle income status by the year 2020. Bananas and plantains exports play a small but growing role in Ghana's export trade. They constitute about 13% of horticultural Agricultural Gross Domestic product (NARP, 1994). Bananas and plantains are among the cheapest foods to produce in Ghana. They are also important sources of rural income (Ortiz and Vuylsteke, 1996). Among staple foods, plantains have the second highest calorie to price ratio after cassava. On the average, plantain supplies 9.5% of the total caloric intake among the Ghanaian population (FAO, 2001).

Many nematode species have been reported to be associated with banana and plantain production (Chabrier and Quénéhervé, 2003; Fogain and Gowen, 1997). However, the most economically important species destroy the primary roots, disrupting the anchorage system and resulting in toppling of the plants. These include the burrowing nematode, *Radopholus similis*, the lesion nematode, *Pratylenchus coffeae* and the spiral nematode, *Helicotylenchus multicintus* (Gowen et al., 2005). Some sedentary endoparasites such as root-knot nematode, *Meloidogyne* spp. (Fargette, 1987) and the reniform nematode, *Rotylenchulus reniformis* (Edmunds, 1971) also parasitize plantains.

Nematodes infestation of plantain fields has various effects on the plant. For instance, *R. similis* attack results

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Table 1. Geo-ecological and climatic description of study sites.

Locality	Location	Mean rainfall (mm)	Mean temperature (ºC)	Relative humidity (%)	Soil type	Production system
Adomakokrom (Brong Ahafo region)	Lat. 6° 27′N Long. 2° 52′W	1,150	25.5	75-80	Forest ochrosols	Mixed cropping
Adanwomase (Ashanti region)	Lat. 6° 44′N Long. 1° 52′W	1,468	26.4	90-95	Granite	Mixed cropping
Mpobi (Ashanti region)	Lat. 1° 51′N Long. 6° 84′W	855	27.0	90-98	Kumasi-Offin Association	Mixed cropping
Kenyasi (Brong Ahafo region)	Lat. 6° 40′N Long. 2° 15′W	1,341	26.5	75-80	Forest Ochrosols	Mixed cropping

in lengthening of the vegetative cycle and toppling of plants especially those bearing fruits. Roots heavily infested by *P. coffeae* show black or purple necrosis of epidermal or cortical tissue and plants stunt, reduce in size and number of leaves and in bunch weight. The effect of *H. multicintus* on plantains is similar to those of *R. similis*. However, in heavy infestations, dieback and lesions in the corm could be observed (Gowen et al., 2005; Quénéhervé and Cadet, 1985). The root-knot nematodes, *Meloidogyne* spp. excite galling on primary and secondary roots sometimes causing them to bifurcate and distort. Stunted growth has also been attributed to *Meloidogyne* spp. (Lin and Tsay, 1985). Higher levels of root rot where *M. incognita* and *Fusarium solani* form association on plantains have also been reported (Sikora, 1979). The cumulative effect of nematodes' damage on plantains result in reduced yields and a global annual loss of 19.7% has been reported (Sasser and Freckman, 1987).

Various control strategies have been employed to manage the menace of plant parasitic nematodes (PPN) in plantain production with varying degrees of successes. Cultural practices such as fallows and rotations with non hosts have been used. However, lack of land has rendered fallows unimportant. Similarly, crop rotation will always be a difficult strategy to implement because of the wide host ranges of nematodes (Sikora and Fernandez, 2005). Physical treatment such as the immersion of suckers in hot water at 55°C for 15 to 25 min has been useful (Stover, 1972), however; failure to monitor the recommended temperature and time limit could prove counter-productive. Biological control has not been employed much as pathogens and parasites of important nematodes of plantains have not yet been identified.

Chemical (synthetic pesticides) method of control has been used with greater measure of success (Thomas, 1996). However, their use constitutes an assault on the environment and a threat to mankind (Bell, 2000). In this present study, we conducted a survey of plantain fields to identify nematodes associated with plantain roots and rhizosphere soils in twenty farms in four districts of Ghana. The information would form the basis of formulating an integrated pest management (IPM) strategy to increase the production of plantain in the country.

MATERIALS AND METHODS

Study sites

The survey was conducted in four districts within two regions of Ghana where plantains are intensively cultivated. One location each was randomly selected from each district. Plantain farms located in Asunafo South, Kwabre East, Afigya Kwabre and Asutifi North districts were evaluated at Adomakokrom, Adanwomase, Mpobi and Kenyasi respectively. Adomakokrom and Kenyasi are in the Brong Ahafo region while Adanwomase and Mpobi are in the Ashanti region. All the locations experience bimodal rainfall pattern. Geo-ecological descriptions of the four locations are presented in Table 1. Two local cultivars: French plantain (Apem) and False horn (Apantu) at different maturity stages were evaluated across locations.

Profile of farmers

Twenty farmers were randomly selected from a population of 40 from four locations (5 farmers per location) using a semi-structured interview and a questionnaire. Both open and closed ended questionnaires were designed, pre-tested, revised and administered to plantain farmers in these study areas. The demographic characteristics of farmers who were selected also had their farms sampled for this study. The gender, age, educational background and farming experience of the selected farmers were analyzed.

Lesion scoring, sampling and extraction of nematodes

Five farms each measuring one acre were randomly selected at each of the four locations making a total of twenty. Three samples per farm were assessed and five functional roots per sample each measuring 10 cm were randomly selected and split and lesions were scored according to the procedure of Speijer and De Waele (1997), where 0 = no damage, 1 = 5% damage, 2 = 10% damage, 3 = 25% damage, 4 = 50% damage, 5 = 75% damage and 6 = 100% damage. Three soil samples per farm were collected from the rhizosphere of the same plants, with a 5 cm diameter soil auger to a depth of 20 cm. Each soil sample (200 cm^3) was stored in polythene bag and carefully labeled. Samples were kept in iced chest to prevent excessive heat. In the laboratory, nematodes were

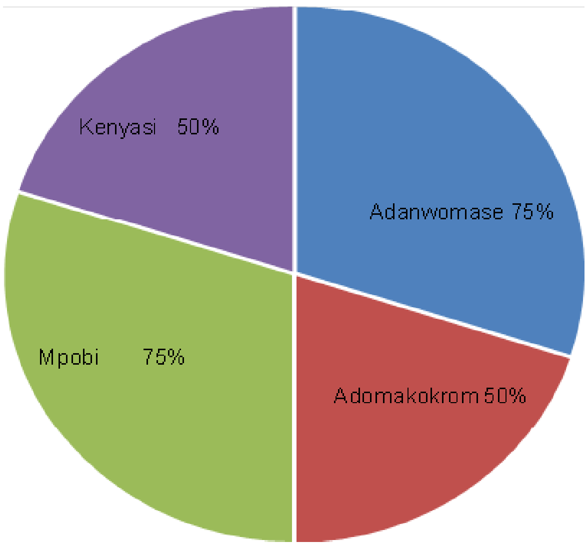

Figure 1. Mean damage scores (percentages) of plantain roots at the four locations surveyed.

extracted from the soil samples using the modified Baermann funnel method (Whitehead and Hemming, 1965).

Motile stages of the nematodes were also extracted from 5 g of plantain roots (three samples/farm), from the same plants used for lesion scoring. The roots were macerated in a blender and extracted using the same extraction method for the soil samples. After 24 h of extraction, nematodes were relaxed in water (60°C) for 3 min and fixed with 40: 1: 89 (formalin: glacial acetic acid: distilled water) and second, third and fourth stage nematodes were mounted on aluminium double-cover glass slides and specimens were identified CIH (1978) using morphological characteristics such as the spear, head skeleton, lumen of the oesophagus, excretory pore and spicules.

Data collection and analysis

Lesion scores, plant parasitic nematodes populations per 200 cm^3 soil and 5 g plantain roots were analyzed. Nematode count data was log [ln (x +1)] transformed to improve homogeneity of variance before analysis using GenStat 8.1 (Lawes Agricultural Trust, VSN International). Means were compared using Fisher's Least Significant Difference (LSD) at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Female farmers constituted 35% (out of a population of 20) while males were 65% of the farmers whose farms were sampled in this study. Approximately half of the plantain farmers in the four districts were females. Most farmers (60%) of the respondents were below 45 years of age. Age is negatively associated with adoption; younger farmers are more likely to adopt new technologies and or are more likely to be early adopters (D'Souza et al., 1993). The level of education among the respondents in the districts was extremely low. The highest educational level was the Senior High School (SHS) certificate obtained by 10% of the respondents and 25% without formal education. Education is positively and significantly associated with adoption. The higher the farmer's educational background, the higher the propensity to adopt technological innovations (D'Souza et al., 1993).
Low level of education as observed in this study, had been reported to affect the level of technology adoption and skills acquisition among farmers (Oyekale and Idjesa, 2009). Illiterate farmers are slow to adopt technologies if they would adopt at all.

Significantly high (60%) had been farming for over 20 to 44 years while 40% had 9 to 20 years experience. Farmers in this study could be described as experienced. Nematode damage to root was estimated visually (as percentage) using a scoring procedure developed by Speijer and De Waele (1997). Farms at Adomakokrom, Adanwomase, Mpobi and Kenyasi recorded 50, 75, 75 and 50% respectively (Figure 1). Thus, plant parasitic nematodes incidence on the farms was high, however, there were no significant differences ($P > 0.05$) amongst the locations covered with respect to root damage. Plantain root damage by plant parasitic nematodes could be a very useful tool to identify resistance or tolerance in varietal screening trials. A variety with no or very low percentage root damage could be resistant to *R. reniformis* and *P. coffeae* which cause root damage in the form of root lesions. Similarly, a variety with severe damage score which records significant yields could be a tolerant genotype. Damage score usually has a strong relationship with crop yield losses (Coyne et al., 2007). Severely damaged roots normally topple-over at the expense of yield, while undamaged root systems have the capacity to support fruit bearing plants till harvest.

Five nematode species were recovered from the rhizosphere of plantain from the four districts surveyed. The nematodes were in the order of importance; *P. coffeae, Meloidogyne* spp., *R. reniformis, R. similis* and *H. multicintus*. Of the five nematode species encountered across locations, soil populations of the root-knot nematodes, *Meloidogyne* spp., and *R. similis* were not different. High populations of *P. coffeae* (803/200 cm^3), *H. multicintus* (292/200 cm^3) and *R. reniformis* (343/200 cm^3) were extracted from soil samples at Adomakokrom, Adanwomase and Adanwomase respectively. Nematode density at Adanwomase was comparatively high. In addition to the high spiral nematode, *H. multicintus* population, it also recorded the highest observed population of the burrowing nematode, *R. similis* (326/200 cm^3) whilst the least (100/200 cm^3) was recorded at Adomakokrom (Table 2)

Nematode infestation of rhizosphere soil was high which reflected in severe root damage scores. Farms in the Ashanti region (Adanwomase and Mpobi) recorded 67% or 3.0 times damage than farms in the Brong Ahafo region (Adomakokrom and Kenyasi). The population of *P. coffeae* at Adomakokrom was 63% more than Kenyasi where the lowest population was recorded. Similarly, the population of *H. multicintus* observed at Adanwomase was 87% more than the lowest observed at Adomakokrom,

Table 2. Plant parasitic nematodes population/200 cm^3 rhizosphere soil.

Location	Meloi	Praty	Roty	Heli	Rado
Adomakokrom	322 (2.4)[‡a]	803 (2.9)[a]	167 (2.2)[b]	39 (1.3)[c]	100 (2.2)[a]
Adanwomase	240 (2.3)[a]	342 (2.4)[b]	343 (2.5)[a]	292 (2.4)[a]	326 (2.5)[a]
Mpobi	217 (2.3)[a]	345 (2.5)[b]	198 (2.2)[b]	95 (1.7)[b]	219 (2.3)[a]
Kenyasi	225 (2.3)[a]	299 (2.3)[c]	159 (2.2)[b]	199 (2.2)[a]	200 (2.3)[a]
P-value	(0.88)	(0.05)	(0.05)	(0.01)	(0.27)
LSD	(0.5)	(0.2)	(0.1)	(0.4)	(0.4)
Cv(%)	(15.4)	(6.2)	(15.9)	(11.7)	(10.8)

Data are means of three replications. [‡]Log transformed [ln (x + 1)] data used in analysis in parenthesis. Meloi = *Meloidogyne* spp., Praty = *Pratylenchus coffeae*, Roty = *Rotylenchulus reniformis*, Heli = *Helicotylenchus multicintus*, Rado = *Radopholus similis.* Figures within a column followed by the same letter do not differ significantly.

Table 3. Parasitic nematodes population/5 g plantain root.

Location	Meloi	Praty	Roty	Rado
Adomakokrom	239 (2.3)[‡a]	433 (2.6)[a]	248 (2.4)[a]	163 (2.0)[a]
Adanwomase	480 (2.6)[a]	527 (2.7)[a]	305 (2.5)[a]	464 (2.6)[a]
Mpobi	596 (2.7)[a]	742 (2.8)[a]	192 (2.2)[a]	419 (2.4)[a]
Kenyasi	341 (2.4)[a]	394 (2.6)[a]	227 (2.3)[a]	351(2.3)[a]
P value	(0.83)	(0.27)	(0.24)	(0.10)
LSD	(0.4)	(0.4)	(0.5)	(0.6)
Cv(%)	(10.3)	(9.4)	(12.4)	(16.8)

Data are means of three replications. [‡]Log transformed [ln (x + 1)] data used in analysis in parenthesis. Figures within a column followed by the same letter do not differ significantly.

Table 4. Comparison of soil and root population densities at the four locations.

Location	Meloi		Praty		Roty		Rado	
	Soil	Root	Soil	Root	Soil	Root	Soil	Root
Adomakokrom	322	239	803	433	167	248	100	163
Adanwomase	240	480	342	527	343	305	326	464
Mpobi	217	596	345	742	198	192	219	419
Kenyasi	225	341	299	394	159	227	200	351
Mean	251	414	447	524	217	243	211	349

Data are means of three replications.

whereas the population of *R. reniformis* was 54% more than the lowest observed at Kenyasi. From Table 3, four parasitic nematodes; *Meloidogyne* spp., *P. coffeae*, *R. reniformis* and *R. similis* were extracted from plantain roots. Root populations were not significantly (P > 0.05) different across locations. The highest observed population of *R. similis* (464/5 g) root occurred at Adanwomase whilst the lowest of (163/5 g) root occurred at Adomakokrom respectively. Compared with soil samples, nematode numbers extracted from root samples were higher (Table 4).

PPN have the potential to rob the plantain farmer of his profits. The menace of PPN has been documented in the West African sub-region (Adiko, 1988; Price, 1994). Nematodes caused on average 50% plantain yield reduction and 20% absolute loss where *P. coffeae* followed by *R. similis* were identified as the major biotic constraint to plantain production in Nigeria (Olaniyi, 2011). The banana weevil, *Cosmopolites sordidus* and the fungus, *Mycosphaerella fijiensis*, the cause of black sigatoka disease are other significant biotic constraints to plantain production but higher losses are anticipated by *P. coffeae* and *R. similis* than by either *M. fijiensis* or *C. sordidus* (Speijer et al., 2001). From the Ivory Coast, Bridge et al. (1995) reported the menace of *P. goodeyi, R. similis, H. multicintus* and *P. coffeae* on plantain production.

Conclusion

This study has shown that farmers have low educational background which could impact negatively on technological innovations adoption. However, the youthful farmer population is insurance for labour. In view of the perceived potential of PPN to destroy and reduce the yield of plantains, conscious efforts must be made to devise a sustainable management option for these pests. Perhaps, the development of resistant varieties could be an essential component of an IPM system.

ACKNOWLEDGEMENTS

The authors acknowledge the Department for International Development (DFID-UK) for co-funding this study with the Conseil Ouest et Centre Africain pour la recherché et le Developpement Agricola (CORAF)/ West and Central African Council for Agricultural Research and Development (WECARD).

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