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 cm³ 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 cm³), H. multicintus (292/200 cm³) and R. reniformis (343/200 cm³) 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
Table 1. Geo-ecological and climatic description of study sites.

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

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 Adomakrom, Adanwomase, Mpobi and Kenyasi respectively. Adomakrom 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 (Apanut) 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 cm³) was stored in polythene bag and carefully labeled. Samples were kept in iced chest to prevent excessive heat. In the laboratory, nematodes were
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 cm³), H. multicintus (292/200 cm³) and R. reniformis (343/200 cm³) 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 cm³) whilst the least (100/200 cm³) 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 cm³ rhizosphere soil.

| Location    | Meloi (2.4) | Praty (2.9) | Roty (2.2) | Heli (1.3) | Rado (2.2) |
|-------------|-------------|-------------|-------------|-------------|------------|
| Adomakokrom | 322         | 803         | 167         | 39          | 100        |
| Adanwomase  | 240         | 342         | 343         | 292         | 326        |
| Mpobi       | 217         | 345         | 198         | 95          | 219        |
| Kenyasi     | 225 (2.3)   | 299 (2.3)   | 159 (2.2)   | 199 (2.2)   | 200        |

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 (2.3) | Praty (2.6) | Roty (2.5) | Rado (2.0) |
|-------------|-------------|-------------|-------------|------------|
| Adomakokrom | 239         | 433         | 248         | 163        |
| Adanwomase  | 480         | 527         | 305         | 464        |
| Mpobi       | 596         | 742         | 192         | 419        |
| Kenyasi     | 341         | 394         | 227         | 351        |

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    | 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 Developpoment Agricola (CORAF)/ West and Central African Council for Agricultural Research and Development (WECARD).

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