Effect of Organic Mulch on Damage to the Roots and Corms of Plantain Suckers by Plant Parasitic Nematodes

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Abstract

The effect of plant parasitic nematodes on the yield and yield trait of plantain (Musa spp-AAB group) cv. Agbagba was assessed in mulched and nonmulched plots. The experiment was sited at the High Rainfall Station of the International Institute of Tropical Agriculture (IITA) in Onne, Nigeria. The inoculum was a natural population mixture of Helicotylenchus dihystera, H. multicinctus, Hoplolaimus pararobustus, Meloidogyne spp. and Radopholus similis. The trial received grass mulch composed predominant of Panicum maximum, Paspalum orbiculae and Cyperus spp., later wood chips composed mainly of Dactyladenia barteri with others such as Cassia spectabilis, Alchornia cordiflora and Anruagana spp. At harvest, higher nematode population densities of the five nematode species were recovered from roots of suckers detached from inoculated plants compared to the uninoculated plants. This revealed that nematode-infected first crop cycle plants would act primarily as a source of inoculum for subsequent crop cycles. Nematode population was suppressed by mulch as nonmulched plants supported higher nematode densities than the mulched plants. Irrespective of the mulching regime, higher percentage of dead roots, root necrosis and corm lesions were observed on suckers detached from inoculated plants compared with those from the uninoculated plants. This showed that plant parasitic nematodes are an important cause of plantain root system weakening.

Keywords: Corm Lesion, Dead Roots, Plantain Suckers, Root Necrosis

Introduction

Plant parasitic nematodes adversely affect the health of plantain by attacking their roots and corm and subsequently hampering uptake of water and mineral nutrients, and reducing plant growth and yield. (Gowen and Quénéhervé, 1990; Rotimi *et al.*, 2004a and b). Heavy losses in plantain usually result from toppling of fruit-bearing stems by wind or heavy rainfall, following destruction of the primary roots by the nematodes (Gowen, 1995). In Nigeria, plant parasitic nematodes caused between 46 % and 54 % production reduction on plantain cv. Agbagba depending on the production practice (Rotimi *et al.*, 2004b). Under severe nematode damage, affected plant topples easily in a windy weather. In Nigeria, plant toppling could be up to 30 % with a general average of 9 % (Speijer *et al.*, 2001).

Plantain production is highly favoured by organic matter supply (Ruhigwa *et al.*, 1995; Rotimi, *et al.,* 2004a and b). Mulching offers a good management option for improved and sustainable plantain production. Plantain is a perennial shrub (Swennen and De Langhe, 1985) in which the damage done to a plant on a mat would impact on the performance of other plants on the mat. There is interconnection of roots of plants on a mat (Blomme, 2000; Shanmugavelu *et al.*, 1992) and this makes the followers (suckers on the mat) act as support for the flowering (mother) plant. Some factors controlling yield traits in the mother plant displayed consistent patterns over crop cycles (Swennen and De Langhe, 1985; Baiyeri, 1998). Hence, the performance of subsequent crop cycles may be predicted by that of the sucker detached from harvested plant.

Therefore, an experiment was setup in Onne, southeastern Nigeria to assess the extent of damage done to plantain suckers by plant parasitic nematodes and the effect of organic mulch in reducing this damage. Plantain cv. Agbagaba (Swennen, 1990), a cultivar popular in Nigeria because of its large fruits/fruits was laid out in a multifactorial experiment. Mulched and nonmulched plants were considered to represent the two cultural practices common among farmers in southern Nigeria. Mulching simulated the backyard gardens, which are close to the homesteads and receive regularly, kitchen and other household wastes and attention. The nonmulched plants simulated the condition of small-scale plantations, which are usually situated at some distance from the homesteads. Such plantations are characterised by poor inputs, including organic mulch, and are often plagued by serious weed problems. This paper reports the effects plant parasitic nematodes and organic mulch on suckers detached from harvested plants, which may be a reflection of expectations on subsequent crop cycles.

Materials and Methods

Planting material, nematode inoculation, treatments: The study was carried out at the High Rainfall Station of the International Institute of Tropical Agriculture (IITA) in Onne, southeastern Nigeria. A total of 320 suckers of plantain (*Musa* spp., AAB-group) cv. Agbagba (Swennen and De Langhe, 1985) were pared and treated in warm water at 53-55 °C for 20 minutes (Colbran, 1967) and left to cool overnight before planting in 25 x 25 x 25 cm black polyethylene nursery bags filled with field soil. Soil was not previously heat sterilised in order to be able to relate our results to the farmer's conditions. Suckers were raised in a screen house and watered daily for four weeks after which, half of the plants were inoculated by adding 150 g nematode-infected root pieces to the soil around the roots of each plant. The remaining half of the plants was left uninoculated. Nematode-infected root pieces were obtained from banana plants (*Musa* spp., AAA-group, cv. Cavendish) growing at the High Rainfall Station. The initial nematode population density per inoculated plastic bag consisted of approximately 4,520 *Radopholus similis*, a mixture of 3,250 *Helicotylenchus multicinctus* and *Helicotylenchus dihystera*, 3,500 *Hoplolaimus pararobustus* and 6,750 second-stage juveniles of *Meloidogyne* spp.

Two weeks after inoculation of nematode inoculated plants, the experiment was established in the field as a multifactorial experiment in a randomized complete block design. Two blocks were established with four plots per block. Each plot sized 16 m x 18 m consisted of 40 plants planted at a spacing of 2 m x 3 m. The blocks represented the replications while the plots represented the treatments. The treatments were 1) nonmulched and noninoculated, 2) nonmulched and inoculated, 3) mulched and noninoculated, 4) mulched and inoculated. The noninoculated treatments did not mean complete absence of plant-parasitic nematodes in the plots, as pre-plant nematode sampling of the plots had revealed the presence of H. multicinctus, Hoplolaimus pararobustus and Meloidogyne spp. in low densities in the soil.

At field establishment of the mulch treatments, grass straw composed predominantly of *Panicum maximum* with some *Paspalum orbiculae* and *Cyperus* spp. was used as mulch to completely cover the plots. Mulch was renewed with wood chips composed predominantly of *Dactyladenia barteri* with some *Cassia spectabilis*, *Alchornia cordiflora* and *Anruagana* spp. at 7 and 14 months after field establishment. For treatments established with inoculated plants, nematode re-inoculation was done 2 weeks after field establishment. Inoculation was done by placing in shallow grooves at the base of each plant, 100 g infected root pieces of Cavendish banana (*Musa* spp. AAA group), which had approximately 8,250 *R. similis*, 13,250 *H. multicinctus*, 6,750 *H. dihystera*, 3,000 *H. pararobustus* and 5,250 second-stage juveniles of *Meloidogyne* spp.

Weed control in the nonmulched plots was by manual slashing at 2 weeks interval for 7 months after which the herbicide gramoxone was applied at 3 weeks intervals at the rate of 2.5 l gramoxone per ha when manual weeding could not be sustained due to the high rate of weed growth. Application of urea at the rate of 60 g per plant and muriate of potash (MOP) at the rate of 100 g per plant was first done on 9 June and later on 7 August and 17 November 1998. In July 1998, nematodes in the uninoculated plots were controlled with one application of nemacur at the rate of 15 g of product per plant. No fungicides were applied throughout the duration of the experiment. The experiment was rain-fed.

Estimation of nematode population densities, root and corm damage: At maturity and harvest of bunches, a sucker was detached from each harvested plants and assessed for damage to the roots and corm. The detached sucker was transported to the laboratory for further study. Roots were detached from the corm of each sucker and the corms were peeled to clearly expose the root bases. The number of root bases on the corm was recorded. The percentages of the root bases with small lesions (SCLP), lesions spread only on one side of the root, and the number of the root bases with large lesions (LCLP), that is lesions encircling the root bases. Root bases with small and large lesions were expressed as percentages of the total number of root bases. Of each sucker, five of the earlier detached roots were randomly selected and reduced to 10 cm lengths. On each of the five roots, feeder root health (FRHI) was assessed on a four-point scale (1-4), 1 being healthy and 4 being completely dead roots. These roots were scored for root necrosis (Speijer and De Waele, 1997). Root-knot was assessed on a two-point scale for each of the sliced five roots. When galling was absent on a root, a score of 0 was given; when galls were observed, a score of 0.1 was given. Root-knot index (RKI) was calculated as the sum of the scores of the five roots.

Nematodes were extracted from roots used for damage assessment. One half of each root was collected and chopped into approximately 2 mm pieces and homogenised. The nematodes were extracted from 5 g sub-samples (Rotimi *et al.*, 2004a). Except for *Meloidogyne* spp. (M), the plant parasitic nematodes were identified to species level under a light microscope and their population densities calculated per 100 g fresh root weight according to the methods described by Rotimi et al. (2004a). Identification was done with the CABI identification manual (CABI, 1972, 1974). Except for *Meloidogyne* spp., the population density of each species was calculated as the sum of all developmental stages (juveniles, females and males). For *Meloidogyne* spp., only the vermiform juveniles and the males could be recovered by the extraction method used.

Data analysis: The data set was collected in August 1999, after 70 % of the first crop cycle plants of the worst performing treatment (i.e. nematode inoculated and nonmulched plants) had been harvested or had toppled or snapped (Table 1). Nematode population densities were log (x+1) transformed (Gomez and Gomez, 1984). Percentage data such as percentages of dead roots and root necrosis were arcsine ($\sqrt{x}/100$)-

transformed while scores and ratios were √(x+0.5)-transformed. The Generalized Linear Model (GLM) procedure of Statistical Analysis System (SAS) was used for the analysis of variance (ANOVA). Whenever significance was detected between a pair of means, the means were compared with the t-test (SAS, 1997).

Results

Effects of treatments on root and corm damage: At harvest, suckers detached from harvested plants, whether mulched or not, had higher percentage dead roots (DP), root necrosis (RNI) as well as higher percentages of small and large corm lesions (SCLP and LCLP), compared to suckers detached from the uninoculated plants (Table 1). The highest values for dead roots (DP), root necrosis (RNI), root-knot (RKI), small corm lesions (SCLP) and large corm lesions (LCLP) were obtained on nonmulched plants that were inoculated. The least values for percentage dead roots (DP), root necrosis (RNI) and small corm lesions (SCLP) were obtained on mulched plants which were not inoculated, while the inoculated plants supported the least root-knot (RKI). The least values for LCLP were obtained on uninoculated plants that were not mulched.

Effects of treatments on nematode population densities: At harvest, suckers detached from harvested inoculated plants had significantly higher densities of *R. similis* whether mulched or not, compared with the uninoculated plants. However, for *H. multicinctus*, densities were only significantly higher on inoculated plants that were not mulched. In general, higher population densities of the five nematode species: *Helicotylenchus dihystera, H. multicinctus, Hoplolaimus pararobustus,* Meloidogyne spp. and *Radopholus similis,* were recovered from roots of suckers detached from inoculated plants compared to the uninoculated plants, with nonmulched plants supporting higher densities than the mulched plants except for *H. pararobustus* (Table 2).

Discussion: Generally, higher population densities of the five nematode species were recovered from roots of the suckers detached from harvested inoculated plants compared to the uninoculated plants. This supports that nematode infected planting material is an important source of nematode infection of plantain in Nigeria (Rotimi *et al.*, 2004 a and b). It also revealed that nematode-infected first crop cycle plants would act primarily as a source of inoculum for other plants on the mat, hence subsequent crop cycles. Root interconnection of plants on a mat (Blomme, 2000; Shanmugavelu *et al.*, 1992) would enhance nematode dispersal all over the mat. Nonmulched plants supported higher nematode population densities than the mulched plants indicating that nematode multiplication was suppressed by mulch. It is likely that certain mineral nutrients provided by the mulch suppressed nematode multiplication (Rotimi *et al.*, 1999) or even prevented root penetration by the nematodes. Talwana (2002) showed that balanced nutrient is necessary for managing nematodes and is of the opinion that deficiency of one nutrient may be detrimental to the root health of bananas. In his study, Talwana observed an increase in numbers of *R. similis* and root damage on banana as nutritional status deviated from the optimum.

The effectiveness of mulching in managing nematode population densities may be due in part to the nutrient status of the soil due to the organic matter provided by the mulch. Organic matter enhances soil biodiversity and it is possible that mulching resulted in a higher number of natural enemies of the nematodes (Goswani and Bhattacharaya, 1989; Pandey and Singh, 1990; Singh *et al.*, 1991; Owino *et al.*, 1993). It is also possible that nematotoxic products were released from the decomposing wood chips (Owino, 1992; Owino and Sikora, 1992; Makhatsa *et al.*, 1993).

Helicotylenchus dihystera and *H. pararobustus* consistently occurred in low population densities in the roots. This could be an indication of their semi-endoparasitic or ectoparasitic feeding habit (Siddiqi, 1972; Baujard and Martiny, 1995a and b). Since our extraction procedure could only isolate nematodes that were within the roots at the time of extraction, it might be useful to extract nematodes from the rhizosphere as this would cater for the ectoparasitic species.

Damage to roots and corms was aggravated by the presence of plant parasitic nematodes in our study supporting the report that plant parasitic nematodes are an important cause of plantain root system weakening (Blake, 1969), subsequently, weakening anchorage on the mat. Corm damage indices (SCLP and LCLP) are important measures of damage by plant parasitic nematodes on plantain since mulch did not have any significant effect on these variables. Root necrosis differed between mulched and nonmulched management practices on the inoculated plants. The nonmulched plants that had the highest root necrosis also had the highest nematode population densities. Root-knotting followed the same trend as root necrosis. This suggests a likely association between root necrosis and root-knotting on plantain cv. Agbagba, contrary to the observations of Blake (1969).

If a favourable environment is sustained, the performance of the follower can be predicted by that of the mother plant (Baiyeri, 1998). Based on the results of our study therefore, we expect production decline on plantain as a result of nematode infection, to progressively increase with each follower. It is expected that the rate of cycling would be faster under mulching while nematode damage is expected to increase progressively with time and become more serious with subsequent followers. In Uganda, gradual increase in the damage to roots and corms of suckers detached from harvested East African Highland bananas by plant parasitic nematodes was observed with each crop cycle (Speijer *et al.* 1999). The authors further observed in Uganda that a mat with a toppled plant risked being unproductive in subsequent crop cycles.

Table 1: Effect of nematode inoculation and mulching on root and corm damage of suckers detached from plantain cv. Agbagba at harvest

Treatment	N	DP	RNI	RKI	FRHI	SCLP	LCLP
				Nonmulched			
Not inoculated	57	8.1	22.9	0.16	3.8	11.7	7.0
Inoculated	18	33.1	50.7	0.29	3.7	26.8	33.4
t-test		*	*	ns	ns	*	*
				Mulched			
Not inoculated	66	4.5	15.3	0.11	3.4	11.0	9.0
Inoculated	27	20.8	43.6	0.09	4.0	20.3	26.2
t-test		*	*	ns	ns	*	*

**: significantly different at P ≤0.05; ns: not significantly different at P = 0.05. N: number of plants assessed; DP: percentage dead roots; RNI: root necrosis index (%); RKI: root-knot index; FRHI: feeder root health index; SCLP: percentage small corm lesions; LCLP: percentage large corm lesions.*

Table 2: Plant parasitic nematode population densities recovered from 100 g fresh roots of suckers detached from plantain cv. Agbagba mother plant at harvest

Treatment	N	Rs	Hm	Hd	Hop	M
			Nonmulched			
Not inoculated	57	423	10,774	228	10	1,077
Inoculated	18	4,651	17,282	1,054	80	1,093
t-test		*	*	ns	*	ns
			Mulched			
Not inoculated	66	185	2,890	78	94	236
Inoculated	27	3,480	7,347	473	31	248
t-test		*	ns	ns	ns	ns

*: significantly different at *P* ≤0.05; ns: not significantly different at *P* = 0.05. N: number of plants assessed; Rs: *Radopholus similis*; Hm: *Helicotylenchus multicinctus*; Hd: *Helicotylenchus dihystera*; Hop: *Hoplolaimus pararobustus*; M: *Meloidogyne* spp.

Hence, yield decline in our experiment is expected to progressively increase with each follower.

Acknowledgement

The study was funded by the Bundes Ministerium für Zusammenarbeit (BMZ), Germany through the International Institute of Tropical Agriculture (IITA). Thanks to Dr. Abdou Tenkouano and Mr. Piers Austin for logistic support. The other authors express deep regret over the dead of Dr. Speijer, Paul in 2000.

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