Comparative Growth and Yield Responses of a False Horn and a French Plantain (*Musa* spp., AAB-Group) to Plant Parasitic Nematodes in Southeastern Nigeria

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Abstract

The effects of plant parasitic nematodes on the growth and yield response of plantain cv. Agbagba, a False Horn, and cv. Obino l'Ewai, a French plantain, (Musa spp., AAB-group) was compared in a mulching experiment at Onne, the High Rainfall station of the International Institute of Tropical Agriculture (IITA).s Nematode inoculum consisted of natural populations of Helicotylenchus dihystera, Helicotylenchus multicinctus, Hoplolaimus pararobustus, Meloidogyne spp. and Radopholus similis. The mulch was composed of wood chips and leaves of Dactyladenia barteri, Cassia spectabilis, Alchornia cordiflora and Anruagana spp. Nematodes caused 48 % yield reduction on cv. Agbagba and 51 % on cv. Obino l'Ewai during the first crop cycle. Almost half (44 %) of the Obino l'Ewai plants toppled over, resulting in zero yield of such toppled plants, while only 27 % of Agbagba plants toppled. Production loss due to plant parasitic nematodes was essentially due to toppling of the plant.

Keywords: Comparative Growth, Yield Responses, False Horn and French Plantain, *Musa* spp., AAB-Group, Plant Parasitic Nematodes, Southeastern Nigeria

Introduction

Plant parasitic nematode species often associated with plantain root damage are *Pratylenchus coffeae*, *Radopholus similis, Helicotylenchus multicinctus* and *Hoplolaimus pararobustus* (Adiko, 1988; Fademi and Bayero, 1993; Bridge *et al.*, 1995; Schill *et al.*, 1996; Rotimi *et al.*, 1999; Speijer *et al.*, 2001). The nematodes cause heavy root and corm damage on plantain, thereby limiting nutrient and water uptake by the roots and subsequently reducing yield (Rotimi *et al.*, 2004 a,b). The authors reported that in Nigeria, plant parasitic nematodes caused between 46 % and 54 % production reduction on plantain cv. Agbagba depending on the mulching practice. The plants whose roots are damaged by plant parasitic nematodes easily topple in a wet and windy weather (Gowen, 1995). In Nigeria, plant toppling could be up to 30 % with a general average of 9 % (Speijer *et al.*, 2001).

In an earlier study, mulch had been demonstrated to enhance plant growth rate, reduce plant parasitic nematode damage on roots, and increase the yield of plantain cv. Agbagba in the first crop cycle (Rotimi *et al.*, 2004a,b). In these studies, mulching supported luxuriant vegetative growth, a faster growth rate and heavier bunches which were harvested earlier than when mulch was not applied. The mulch also reduced the adverse effects of plant parasitic nematodes on plantain cv. Agbagba yield as inoculated plants produced bunches of similar weights as those of the uninoculated plants. The inoculated plants that were mulched still yielded better than the unmulched plants. Although plantain cvs Agbagba and Obino l'Ewai raised from tissue cultured plants do not differ significantly in dry matter production, plants raised from field suckers produced significantly different dry matter (Blomme and Ortiz, 1995).

Plantain cv. Agbagba, a False Horn, is the most preferred plantain cultivar in Nigeria because of its large fingers (Chukwu, 1997), while cv. Obino l'Ewai, a French plantain is popular in plantain breeding because of its relatively high seed setting ability when crossed (Swennen and Vuylsteke, 1988a,b; Vuylsteke *et al.*, 1993). Again, these two cultivars are commonly cultivated in West and Central Africa (Swennen and Vuylsteke, 1987). It was considered necessary to investigate the possible differences in yield response to plant parasitic nematodes.

Materials and Methods

The experiment was located at the High Rainfall Station of the International Institute of Tropical Agriculture (IITA) in Onne, Rivers State, Nigeria. Onne is situated in a high rainfall mangrove forest region of Nigeria. It is located on longitude 7 ° E and latitude 5 ° N at 10 m above sea level. Prior to the establishment of the experiment in the field, the land had been under natural re-growth fallow for 3 years. The land was cleared and ploughed a year before the establishment of the experiment. Thereafter, the field was slashed mechanically at regular intervals of 2-3 months until utilised for the experiment. A month to field establishment and 2 weeks after, the field was sprayed with grammoxone herbicide at the rate of 2.5 l per hectare. Afterwards, no herbicide was applied

throughout the duration of the experiment. Hand weeding was done whenever necessary.

Planting material, nematode inoculation and field layout: A hundred and sixty eight suckers of cv. Agbagba and cv. Obino l'Ewai were pared and pseudostem length reduced to about 30 cm. They were then treated in 55 ^{o} C warm water for 20 minutes according to the procedure of Colbran (1967). Hot water-treated suckers were left to cool overnight and planted in 20 x 20 x 20 cm black polythene nursery bags filled with heat sterilised field soil. Suckers were planted in the bags between 24 and 29 June 1998. Suckers were inoculated with 100 g nematode infected root pieces collected from nematode infected banana (cv. Valery, AAA-group) plants and chopped into approximately 2 mm long pieces. The inoculum was buried in a shallow trench at the base of each plant 2 months (August 1998) after nursery planting. The inoculum contained estimated population numbers of 400 *H. multicinctus*, 100 *H. pararobustus*, 350 *Meloidogyne spp.* and 1,500 *R. similis*. The nematode inoculum consisted of all developmental stages of the different species except for Meloidogyne spp., where only the second stage juveniles (J_2s) were used. Half of the total plants per cultivar were inoculated. Inability of obtaining high nematode population densities in the inoculum delayed inoculation until 2 months after planting in the nursery. Inoculation was repeated 2 weeks (September 1998) after the first inoculation in order to raise the inoculum density. The inoculum contained estimated population densities of 15 R. similis, 310 H. multicinctus and 325 *Meloidogyne spp.* per 100 g roots. Three weeks later, plants were established in 35 x 35 x 35 cm planting holes in the field at a spacing of 3 x 2 m. The trial was laid out in a randomised complete block design of two blocks with four plots per block.

Each of the four treatments was randomly assigned to each of the four plots in each block. Twenty one plants were arranged in each plot sized 18 x 4 m, at a spacing of 2 m x 3 m. The blocks represented the replications while the plots represented the treatments. The treatments were 1) cv. Agbagba and not inoculated, 2) cv. Agbagba and inoculated, 3) cv. Obino l'Ewai and not inoculated, 4) cv. Obino l'Ewai and inoculated. The pre-plant nematode sampling of the experimental field had revealed the presence of *H. multicinctus, H. pararobustus* and *Meloidogyne* spp. in low densities in the soil (Rotimi *et al.*, 2004a). Blocks and plots were each separated by 6 m alleys. The outer borders of the plots were planted randomly with cv. Agbagba and cv. Obino l'Ewai.

At field establishment all plots were completely covered with a 9 cm thick layer of wood chips and leaf mixtures of *Dactyladenia barteri, Cassia spectabilis, Alchornia cordiflora* and *Anruagana* spp. Two months after field planting (November 1998), fertilisers were applied at the rate of 100 g muriate of potash and 60 g urea per plant. Fertiliser application was done three more times at 2 months interval. Mulching was repeated 5 months (February 1999) after field establishment.

Assessment of plant growth: Plant growth was assessed at the reproductive phase. Data was collected separately at flowering and harvest. At flowering, height of pseudostem from soil level to the point of flower emergence (FHT) and the girth of the pseudostem at soil level (FGTH) was measured for each mother plant. The number of suckers produced at flowering (FSUC) was recorded while the number of functional leaves at flowering (FFL) was also recorded. A leaf was considered to be functional if at least 75 % of the lamina had not senesced; otherwise, it was considered non-functional. The dates on which the plants flowered were also recorded. Flowering day was considered as the day on which the inflorescence first became visible. The number of days to flowering (DF) was determined as the average number of days it took a plant to flower (DF) from the day of planting out in the field.

Harvest data were compiled when at least 60 % of the poorest performing treatment had flowered. The number of functional leaves at harvest (HFL) was recorded. The number of suckers produced at harvest (HSUC) was also recorded. The number of days to harvest (DH) was determined as the average number of days it took a plant to be harvested (DH) from the day of planting out in the field. The number of days for fruit filling (DFF) was calculated as the number of days between flowering and harvest. At harvest of the mother plant, growth parameters on the tallest sucker including the height (TSHT) and the girth of the pseudostem at oil level (TSGTH) were assessed.

Estimation of yield: The bunch was harvested when the calyx was completely senesced from all the fruits. Bunches were cut at the second cylindrical ring on the fruit stalk (rachis) behind the first hand from the proximal end of the bunch. Bunch weight (BW) was determined immediately in the field after harvest using a Salter Model 239 weighing balance. Weight was recorded for each mature harvested bunch and production estimates per hectare were calculated for the first crop cycle. Numbers of plants that toppled and snapped were also recorded. Percentage of plants that toppled was calculated as total number of plants that toppled divided by total number of plants that were established.

Estimation of nematode population densities: At pre-flowering (178 DAP) stage, nematodes were extracted from five randomly selected from a 20 x 20 x 20 cm excavation at the base of each sampled plant. Each root was reduced to 10 cm and chopped into approximately 2 mm pieces and properly homogenised. A 5 g subsample was macerated for 15 seconds in a kitchen blender and nematodes were extracted overnight during 18 hours using a modified Baermann funnel method (Hooper, 1990). Nematode extraction was done separately for the primary and the secondary roots. The secondary roots were carefully severed from the primary roots before chopping the root segments into 2 mm pieces. When the secondary root weight was less than 5 g, the total was used for extraction. Nematodes were identified to species

level with a light microscope using the CABI identification manual (CABI, 1972, 1974). Nematode population densities were calculated per 100 g fresh roots. Nematode numbers consisted of adult males, females and juveniles, except for Meloidogyne spp. for which only second stage juveniles (J2's) and males are reported.

Data analysis: Data analysis was performed with Statistical Analysis System (SAS) software (SAS, 1997). The GENMOD procedure was employed in the analysis of variance of nematode population densities and count variables of growth parameters at the flowering phase. Means were separated using the Student's t-test when statistical differences were observed. Prior to analysis, the nematode population densities were log (x+1) transformed (Gomez and Gomez, 1984). The number of functional leaves was used without transformation.

Results

Effects plantain genotype and nematode inoculation on growth parameters and yield: At the time of data summarisation, all the plants in the inoculated plots of cv. Obino l'Ewai were established while, for each of the other treatments, 98 % of the plants were established (Table 1). Of the established plants, 98 % and 95 % had flowered of the uninoculated cv. Agbagba and cv. Obino l'Ewai plants, respectively, while 66 % and 60 % of the plants had flowered of the inoculated treatments of cv. Agbagba and cv. Obino l'Ewai, respectively. In the uninoculated treatments 85 % and 83 % of the established plants were harvested for cv. Agbagba and cv. Obino l'Ewai, respectively, while, only 46 % and 38 % were respectively harvested of the inoculated plants of cv. Agbagba and cv. Obino l'Ewai (Table 1).

Plant parasitic nematode inoculation was associated with 27 % and 44 % toppling for cvs Agbagba and Obino l'Ewai, respectively (Table 1). Total number of plants that toppled = PF+IB+HB where PF = number of plants that toppled at pre-flowering stage, IB = number of plants that toppled with immature bunches and HB = number of plants that toppled with matured bunches. Inoculated treatments had 48 % and 51 % lower harvest for cvs. Agbagba and Obino l'Ewai, respectively.

Bunch yield (BW) ranged between 4.4 kg and 5.3 kg for the two cultivars (Table 2). Average bunch weight of cv. Obino l'Ewai was 6 % lowered by plant parasitic nematodes while that of Agbagba was reduced by 14 %. At flowering, cv. Agbagba plants that were inoculated had larger area for the youngest leaf than inoculated cv. Obino l'Ewai plants. At harvest, inoculated cv. Agbagba plants had more number of functional leaves than cv. Obino l'Ewai plants that were inoculated, while the reverse was the case with the non-inoculated plants. The tallest suckers on the mats of cv. Agbagba plants that were not inoculated had higher values than those on similarly treated cv. Obino l'Ewai plants.

Effects of nematode inoculation and plantain genotype on nematode population densities recovered from plants at the vegetative stage: *Meloidogyne spp.* were not observed in either primary or secondary roots of uninoculated cv. Agbagba plants, while R. similis and H. multicinctus were not detected only in the primary roots of uninoculated cv. Agbagba plants (Table 3). Population densities of all the nematode species were generally low in the inoculated plants whether in the primary or the secondary roots for both genotypes; except for H. multicinctus which had lower population densities in the secondary roots of cv. Agbagba. The highest population density obtained per 100 g fresh roots for any species was that of *R. similis* (4,729) observed in the primary roots of inoculated cv. Obino l'Ewai plants. In the secondary roots, the highest population density obtained per 100 g fresh roots was 2,455 of H. dihystera observed in the uninoculated cv. Obino l'Ewai plants (Table 3).

Effect of nematode inoculation and plantain genotype on nematode population densities recovered from plants at the vegetative stage: *Meloidogyne spp.*, were not observed in either primary or secondary roots of uninoculated cv. Agbagba plants, while *R. similis* and *H. multicinctus* were not detected in the primary roots of uninoculated cv. Agbagba plants (Table 3). Population densities of all the nematode species were generally low in the inoculated plants whether in the primary or the secondary roots for both genotypes; except for *H. multicinctus* which had lower population densities in the secondary roots of cv. Agbagba. The highest population density obtained per 100 g fresh roots was 2,455 of *H. dihystera* observed in the uninoculated cv. Obino l'Ewai plants (Table 3).

Discussion

On the corm of the suckers detached from harvested plants, root damage increase was higher with inoculation than without inoculation. This would weaken anchorage of plants on the mat. Compared with cv. Obino l'Ewai, cv. Agbagba is likely to be a better host of all nematode species in subsequent crop cycles because of the higher population densities observed in the roots of suckers detached from harvested plants. It is likely that the population densities of these nematode species will quickly build up under cv. Agbagba and the damaging effect of plant parasitic nematodes is expected to become more pronounced on subsequent crop cycles of cv. Agbagba compared to cv. Obino l'Ewai. Wilson et al. (1985) have observed the poor ratooning of plantain cultivar Agbagba. Even when organic mulch and inorganic fertiliser were applied, only 30 % survival rate was obtained in the second ratoon. It means that the plant parasitic nematodes will aggravate the poor survival of ratoons of cv. Agbagba. In a pot experiment at the vegetative stage (Rotimi, 2003), cv. Obino l'Ewai was observed to be a better host of plant parasitic nematodes than cv. Agbagba and the former genotype also sustained more root damage when

Table 1: Summary of production estimates for the first crop cycle of plantain cvs. Agbagba and Obino l'Ewai established in mulched plots inoculated or not inoculated in Onne

Treatment	Production estimate (kg /ha)	Number Planted	Dead	Broken	Number toppled F	H	PF	IB	HB
				Not Inoculated					
Agbagba	7,258	42	1	1	40	35	0	1	0
Obino l'Ewai	7,327	42	1	0	39	34	0	0	0
				Inoculated					
Agbagba	3,757	42	1	0	27	19	9	0	2
Obino l'Ewai	3,572	42	0	0	25	16	11	3	2

F: flowered plants; H: harvested plants; PF: pre-flowering; IB: immature bunch; HB: harvestable bunch.

Table 2: Effects of nematode inoculation on root damage parameters, root fresh weight and root diameters of plantain cvs Agbagba and Obino l'Ewai, 178 days after planting

Treatment	RNI	RKI	DP	FRHI	WWP	WWS	DWP	DWS	Dbase	Ddistal
					Not inoculated					
Agbagba	9.3a	0.7a	0.4a	3.0a	22.9a	2.6a	2.9a	0.63a	0.49a	0.41a
Obino l'Ewai	11a	0.6a	0.8a	2.7a	21.6a	2.1a	2.9a	0.56a	0.44a	0.40a
					Inoculated					
Agbagba	18.6a	0.5a	24.2a	2.7a	20.7a	1.37b	2.7a	0.39a	0.41a	0.37a
Obino l'Ewai	18.9a	0.5a	17.3b	2.7a	19.8a	2.13 a	2.7a	0.59a	0.41a	0.36a

Means followed by the same letter are not significantly different by within columns of not inoculated and inoculated at P ≤ 0.05. RN: percentage of root necrosis; RK: root-knot index of the primary roots; DP: percentage of dead roots; FRHI: feeder root health index; WWP: fresh weight of primary roots; WWF: fresh weight of feeder roots; DWP: dry weight of primary roots; DWF: dry weight o feeder roots; Dbase: diameter of the root end proximal to the base of plant; Ddistal: diameter of the root end distal to plant base.

Table 3: Population densities of plant parasitic nematode species recovered from inoculated and uninoculated plantain cvs Agbagba and Obino l'Ewai, 178 days after planting

Treatment	Rs	Hm	Hd	Hop	M
	Primary roots (number/100 g fresh roots)				
			Not inoculated		
Agbagba	0a	0a	125b	208a	0a
Obino l'Ewai	25a	50a	442a	83b	33a
			Inoculated		
Agbagba	1,892b	296a	490b	177a	42b
Obino l'Ewai	4,729a	296a	829a	246a	4,654a
	Secondary roots (number /100 g fresh roots)				
			Not inoculated		
Agbagba	8a	300a	608b	1,458a	0a
Obino l'Ewai	46a	33b	2,455a	412b	50a
			Inoculated		
Agbagba	167b	104a	313a	188a	115b
Obino l'Ewai	1,608a	153a	2,306a	316a	1,771as

Means followed by the same letter are not significantly different within columns of noninoculated and inoculated. Rs: Radopholus similis; Hm: Helicotylenchus multicintus; Hd: Helicotylenchus dihystera; Hop: Hoplolaimus pararobustus; M: Meloidogyne spp.

inoculum densities contained less than 10,000 R. similis. When the inoculum contained 10,000 R. similis, however, root necrosis on cv. Agbagba suddenly became higher than that on cv. Obino l'Ewai.

The results of the first crop cycle suggested that plantain cv. Agbagba was less stressed by plant parasitic nematodes than cv. Obino l'Ewai. This supports earlier observations of Rotimi (2003). However, the susceptibility of each genotype is likely a function of nematode inoculum level (Rotimi, 2003). It will be necessary to ascertain for each genotype, the optimum inoculum pressure under which plant productivity will decline. Our understanding of nematode-host (plantain)-environment is still scanty. More focused studies should be directed at plantain root reactions under different nematode pressure level and the contribution of the environment to this interaction.

The threshold level at which root damage would adversely affect plantain growth, anchorage and bunch yield must be established before we can effectively classify accessions in the gene bank as resistant or susceptible, tolerant or sensitive.

Root necrosis index and percentage of dead roots were strongly associated with nematode inoculation at the pre-flowering stages, irrespective of genotype and are thus, good indicators of nematode damage on plantain. Earlier (Rotimi *et al.*, 2004 a,b), the two indices have been identified as good indicators of nematode damage on plantain cv. Agbagba; whether in the mulched or nonmulched treatment. The diameter of the primary roots may also be used to further assess the damage of plant parasitic nematodes on plantain. In the present study, there were thicker roots on the uninoculated plants of both cv. Agbagba and cv. Obino l'Ewai than on the inoculated plants.

Table 4: Effects of nematode inoculation on plant growth parameters at pre-flowering, flowering and harvest of plantain cvs Agbagba and Obino l'Ewai. (insert pre-flowering data)

Treatment	Flowering					
	FHT (cm)	FGTH (cm)	FYLA (cm^2)	FFL	FSUC	DF
			Not inoculated			
Agbagba	252.9a	60a	3461.6a	8.3a	6.6a	285a
Obino l'Ewai	251.3a	58a	3471.3a	8.2a	5.9a	292a
			Inoculated			
Agbagba	236.7a	57.5a	3066.6a	8a	6.7a	289a
Obino l'Ewai	242.9a	57.8a	2444.7b	9a	7.3a	276a

	Harvest						
	TSHT (cm)	TSGTH (cm)	BW (kg)	HFL	HSUC	DH	DFF
				Not inoculated			
Agbagba	123.1a	38.6a	5.1a	0.2b	7.1	349a	74a
Obino l'ewai	118.2a	37.2b	5.3a	0.4a	7.5	357a	79a
				Inoculated			
Agbagba	97.5a	29.3a	4.4a	0.8a	7.7	360a	78a
Obino l'ewai	93.7a	29.1a	5.0a	0.3b	8.7	351a	80a

Means not significantly different at $P \leq 0.05$ within columns of noninoculated and inoculate. DF: number of days from field establishment to flowering; FHT: height of mother plant at flowering; FGTH: girth at flowering of pseudostem of mother plant at soil level; FFL: number of functional leaves at flowering; FYLA: area of youngest leaf opened at flowering; FSUC: number of suckers at flowering; DH: number of days from field establishment to harvest; DFF: number of days for fruit filling; BW: bunch weight at harvest; HFL: number of functional leaves at harvest; HSUC: number of suckers at harvest; TSHT: height of tallest sucker at harvest of mother plant; TSGTH: girth of pseudostem of tallest sucker (at soil level) after the harvest of mother plant.

Table 5: Effect of nematode inoculation on the reproductive growth and yield of the first crop cycle of plantain cvs Agbagba and Obino l'Ewai

Treatment	Root damage at flowering			
	DP	RNI	RKI	FRHI
		Not inoculated		
Agbagba	5.2a	13.8a	0.20a	3.23a
Obino l'Ewai	5.3a	13.7a	0.21a	3.33a
		Inoculated		
Agbagba	26.9a	51.2a	0.27a	3.30a
Obino l'Ewai	22.1a	46.2b	0.23a	3.17a

	Root and corm damage at harvest[1]						
	DP	RNI	RKI	FRHI	TOTR	SCLP	LCLP
				Not inoculated			
Agbagba	8.9a	19.7a	0.10a	3.8a	17a	7.6a	6.5b
Obino l'Ewai	3.0b	15.6b	0.11a	3.9a	20a	7.3a	23.7a
				Inoculated			
Agbagba	41.4b	51.1a	0.08a	3.7a	16a	20a	23.7a
Obino l'Ewai	47.2a	46.6b	0.09a	3.6a	13a	18.6b	25.8a

[1]*Assessment done on suckers detached from harvested mother plants. Means followed by the same letter are not significantly different at $P = 0.05$ within columns of not inoculated and inoculated. DP: percentage dead roots; RNI: root necrosis index (%); RKI: root-knot index on the primary roots; FRHI: feeder root health index; TOTR: total number of roots; SCLP: percentage of small lesions on the corm of suckers detached from harvested plants; LCLP: percentage of large lesions on the corm of suckers detached from harvested plants.*

Table 6: Effect of nematode inoculation on plant parasitic nematode densities recovered from plantain cvs Agbagba and Obino l'Ewai plants at flowering and suckers detached from harvested plants

Treatment	Flowered plants				
	Rs	Hm	Hd	Hop	M
			Not inoculated		
Agbagba	519a	2,628a	132a	102b	1,149a
Obino l'Ewai	168b	962b	123a	183a	826b
			Inoculated		
Agbagba	9,516b	4,882a	162a	86a	222b
Obino l'Ewai	12,531a	4,640b	155a	7b	266a
	Harvest				
			Not inoculated		
Agbagba	449a	6,731a	2b	28a	125b
Obino l'Ewai	36b	524b	22a	67a	333a
			Inoculated		
Agbagba	13,710a	8,254a	129a	137a	0a
Obino l'Ewai	2,964b	6,409b	99b	52b	0a
	Toppled plants				
			Not inoculated		
Agbagba	0	0	0	0	0
Obino l'Ewai	0	0	0	0	0
			Inoculated		
Agbagba	16,279	4,560	0	208	49
Obino l'Ewai	11,576	8,873	74	23	1742

Means followed by the same letter (s) are not significantly different at $P = 0.05$ for flowering and harvest. Rs: Radopholus similis; Hm: Helicotylenclus multicintus; Hd: Helicotylenchus dihystera; Hop: Hoplolaimus pararobustus; M: Meloidogyne spp.

This showed that plant parasitic nematodes are an important factor of thinning of the primary roots and that apart from damaging the roots, their parasitic habit would also result in reduced thickness (diameter) of the roots. This probably will have some other effects like reduced efficiency of nutrient pull from the soil into the roots, which have not yet been established. The results also pointed to the fact that plant parasitic nematodes are important along the entire length of the roots, since the diameter of the primary roots was reduced by these nematodes irrespective of the distance from the base of the plant. Talwana (2002) discovered on banana plants in Uganda that plant parasitic nematodes are spatially distributed throughout the length of the roots and that they equally cause damage no matter their distance to the root base. The damage to the secondary roots did not show any relationship with nematode inoculation and hence may not be a good indicator of nematode damage. Nevertheless, the fresh weight of these secondary roots was reduced by the inoculation of plant parasitic nematodes. This suggests that this parameter (fresh weight) might be an important determinant of nematode damage on the secondary roots, rather than the feeder root health index commonly used.

That bunch yield was not repressed by plant parasitic nematodes in this mulched study is in line with earlier results (Rotimi *et al.*, 2004b). In their study, Rotimi *et al.*, (2004b) had observed 46 % reduction in production of mulched cv. Agbagba plants and 23 % toppling of plants bearing immature bunches when the cv. Agbagba plants were mulched.

Although mulching is an effective cultural practice option in modulating nematode effects in plantations under low nematode inoculum pressure (Rotimi *et al.*, 1999), losses were still incurred due to failure (toppling), which means zero harvest from such plants as well as reduction in bunch yield on hectarage basis. Hence, mulch supported 63 % production capability of cv. Agbagba and 56 % of cv. Obino l'Ewai when plant parasitic nematodes limited production. Of this capacity, production estimate on hectarage level gave 48 % and 51 % yield loss for cv. Agbagba and cv. Obino l'Ewai, respectively. This implies that plant parasitic nematodes could be more deleterious on cv. Obino l'Ewai than cv. Agbagba in the first crop cycle. This underscores the importance of clean planting materials in nematode management (Sarah, 1989; Bridge *et al.*, 1995; Rotimi, 1996; Rotimi *et al.*, 2004a). Although there is likely to be higher incidence of plant failure (toppling) when nematodes limit fruit filling of the two genotypes, cv. Agbagba performed better than cv. Obino l'Ewai in terms of number of plants that were harvested in the first crop cycle. Production estimates of bunch yield on hectarage basis of plants that were harvested revealed less than 50 % reduction in bunch yield for cv. Agbagba while for cv. Obino l'Ewai, it was more than 50 %.

Availability of nematode inoculum was a major problem in our study. It takes time to build up nematode population densities that will be adequate for pathogenicity studies. Therefore, for such studies, it will be necessary to build up a ready source of inoculum. Studies with single species and pre-determined species mixtures will be necessary in order to acquire adequate and systematic information on plantain reactions to these pathogens singly and in concomitance. Such information is paramount to developing cultivars resistant to important nematode species and to understanding the pathogenic status and economic importance of plant parasitic nematode species on plantain.

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