VARIABILITY OF NEMATODE COMMUNITY STRUCTURE AND GRAIN YIELD IN ORGANIC FERTILISER AMENDED SOYBEAN FIELD

Lawal, R.O[1]., Atungwu J.J[1*]., [1]E.I. Ayo-John and Kehinde, O.B[2].

[1]Department of Crop Protection, Federal University of Agriculture Abeokuta Ogun State, Nigeria. [2]Department of Plant Breeding and Seed Technology, Federal University of Agriculture Abeokuta Ogun State, Nigeria

*Corresponding author, e-mail: jojerat1@yahoo.com

ABSTRACT

Three novel Nigerian-based organic fertilisers coined Gateway, Sunshine and Neem were tested in comparison with one synthetically compounded inorganic fertiliser, $N_{15}P_{15}K_{15}$ for their effects on the trophic groups of nematodes in one soybean field each at Abeokuta and Ayetoro. The study hypothesized that fertiliser types would influence population changes of the various nematode trophic groups. The organic fertilisers were manually incorporated into the soil two weeks before planting at recommended rate of 5 t ha^{-1} and 120 kg ha^{-1} of $N_{15}P_{15}K_{15}$ two weeks after planting. Unamended plots served as the control. Treatments were arranged in Randomized Complete Block Design and replicated four times. Nematode population density was estimated from 250g soil sample per replication before incorporation of organic fertiliser and at harvest, and identified to the genus level. Nematodes recovered were grouped into the trophic groups as bacterivores, fungivores, predators, omnivores and herbivores. Data were collected bi-weekly on soybean plant height, stem girth, number of leaves and grain yield at harvest maturity. Data were subjected to analysis of variance and treatment means were separated using the new Duncan's Multiple Range Test. Eleven plant-parasitic and free-living nematode spp. were encountered. Pooled data showed that plant-parasitic nematodes were suppressed by 39.17%, 36.39% and 34.16% in plots amended with Sunshine, Neem and Gateway fertilisers, respectively. Bacterivorous and fungivorous nematodes increased in plots treated with organic fertilisers which resulted in the lower Fungi-to-Bacteria and higher Bacteria-to-Plant-parasitic ratios concomitant with the corresponding increase in grain yield in organic-amended plots of the TGx 1019-2EN soybean variety studied. The Plant-Parasitic Index (PPI) and Maturity Index (MI) were consistently lower ($P<0.05$) in the Neem and Sunshine-amended plots compared to Gateway fertiliser-amended plots.

Keywords: Bacterivores, fungivores, herbivores, omnivores, organic-fertiliser

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a remarkable leguminous crop and a prominent source of protein for animal diets and human nutrition (IITA, 2001). Since its introduction into Nigeria in 1908 (Fennel, 1966), soybean production continued to increase (Ekenta, 2013) in the last 107 years. Although, major producers of soybean are USA (83.2 mmt), Brazil, (65.5 mmt) and Argentina (41.0 mmt); accounting for 83.01% of total world production (SOYSTATS, 2011). In Africa, a continent contributing less than 1% to the global production (IITA, 2001), Nigeria is the leading soybean producer (Atungwu *et al*., 2005)., .

One of the commonly grown soybean cultivars in Nigeria, TGx 1019-2EN, has been documented to be susceptible to *Meloidogyne incognita* (Afolami, 2000; Atungwu, 2004) with colossal losses from infested fields (Atungwu, 2008). Previous studies (Afolami and Atungwu 1999; 2001, Atungwu *et al*., 2001; Adegbite *et al*., 2005) reported susceptibility of soybean genotypes to the root-knot nematodes, *Meloidogyne* spp. due to lack of purposeful breeding for nematode resistance in Nigeria (Atungwu *et al*., 2005).

Nematodes do not only cause direct damage to the crop but also aid the susceptibility of soybean to various diseases through wounds caused by it. Nematode population and disease management is highly challenging because of the wide host range of this pest. However, various methods have been utilised successfully to manage plant-parasitic nematodes in agricultural soils (Adesiyan *et al*., 1990). Chemical, biological, and cultural methods along with the use of host plant resistance comprised management strategies that have decreased the risk of damage by many phytophagus nematode species (Starr and Roberts, 2004). Nevertheless, the suppressive effects of some of these strategies on non-target and/or beneficial organisms including nematodes make them inadequate for sustainable production (Renčo *et al*., 2010)

In the last 15 years, most chemical nematicides were deregistered due to the risks their application posed to the environment (USEPA, 2011) and beneficial organisms. Organic soil amendments resulted in a reasonable suppression of phytophagus nematode populations (Akhtar and Malik, 2000) by adding competitive, predaceous, or antagonistic microbes to soil (Renčo *et al.*, 2010). Crop residues and poultry litter have received immense attention as management options for phytonematodes (Koenning and Barker, 2004; Atungwu *et al.*, 2012). Unlike compounded synthetic nematicides, organic fertiliser addition to soil increased the populations of bacterivorous and fungivorous nematodes (Griffiths *et al.*, 1994; Atungwu *et al.*, 2012). Adekunle *et al*. (2015) reported 16.25 - 65.75% reductions in the population of all five plant-parasitic nematodes encountered in compost amended plots compared to an increase in the population of the untreated control plots. Communities of these nematodes are analysed based on several methodologies developed (Bongers and Ferris, 1999).

An effective tool for characterising disturbance and enrichment is the Maturity Index (MI) but a more effective index used by Plant Nematologists is the Plant-Parasitic Index (PPI), which is easily estimated because plant-parasitic nematodes are often identified to generic or species level (Bongers and Ferris, 1999). Simple ratios such as the bacterivore-to-fungivore ratio and the bacterivore-to-plant-parasitic ratio have also demonstrated promise in measuring the activities of decomposers in nutrient cycling (Neher, 1995).

Organic agriculture is a production system that sustains the health of soils, ecosystems, biodiversity and people through combination of traditional knowledge, innovation and modern science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM 2004; AdeOluwa, 2010). Animal manure and compost remain the most common source of soil amendment in organic agriculture in Nigeria and indeed Africa (Omiti *et al*., 1999), there is therefore, the need for commercial production of organic based fertiliser if organic farming is to be considered for large scale farming.

Despite several years of soybean research and nematode management with organic materials in Nigeria empirical information on the effects of organic fertiliser on nematode population dynamics is still scanty in literature. Hence, this study aimed at comparing the structure and composition of nematode communities in soils amended with three different organic fertilisers.

MATERIALS AND METHODS

Experimental Sites:

Field experiments were conducted simultaneously in July and October, 2013 in the Teaching and Research Farms, Federal University of Agriculture, Abeokuta Ogun State (07^{o} 15' N; 3^{o} 35' E) and Training and Research Farms, College of Agriculture, Olabisi Onabanjo University, Ayetoro, Ogun State (07^{o} 14' N; 3^{o} 2' E). The experimental fields were fallowed for two years prior to the trial. *Meloidogyne* species-susceptible variety of soybean, TGx 1019-2EN obtained from the International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria was sown in both fields. Three newly manufactured organic fertilisers were sourced. They included Neem Fertiliser produced by the National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State with pH of 7.07, organic carbon 37.69%, nitrogen 3.24%. phosphorus 3.28% and potassium 2.73%; Sunshine Organic Fertiliser produced by the Ondo State Government Akure with pH of 9.03, organic carbon 76.74%, nitrogen 3.50% phosphorus 1.00% and potassium 1.20%; and Gateway Organic Fertiliser produced by the Ogun State Government with pH of 7.50, organic carbon 53.95%, nitrogen 2.10%. phosphorus 3.41% and potassium 2.15%. The experiment was laid out in a Randomized Complete Block Design with five treatments replicated four times. Each plot was 1.0 m x 3.0 m with 0.3 m alley between each plot, and an alley of 0.5 m between adjacent blocks. There were a total of 105 soybean plant stands per plot with a planting spacing of 75 cm x 5 cm. The organic fertilisers were manually incorporated at recommended rate of 5 t ha^{-1} two weeks before planting to allow adequate mineralization. Basal application of $N_{15}P_{15}K_{15}$ at recommended rate of 120 $kgha^{-1}$ was made two weeks after planting as check while the control plots had no fertiliser treatment. Soybean seeds were not dressed with pesticides and were sown two to three seeds per hole and later thinned to one plant per stand at one week after emergence. The fields were kept free of weeds by manually removing the weeds at four, six and eight weeks after planting.

Soil Sampling and Nematode Extraction

The initial and final populations of nematodes were sampled and estimated pre-planting and at harvest, respectively. A bulk, consisting of 20 randomly selected soil cores was collected from each plot. Nematodes were extracted from 250 g of soil, extraction was done according to tray method described by Whitehead and Hemming (1965). Individual nematodes from each sample were examined at 100 – 400X under a light microscope then identified to genus level using the interactive Diagnostic Keys of Plant-Parasitic, Free-living and Predaceous nematodes. (Decraemer and Hunt, 2006; Mekete *et al*., 2012) from each sample and then assigned a c–p (colonizer-persister) value (Bongers and Ferris, 1999).

Data Collection and Analysis

Agronomic data were collected from six previously tagged middle row plants bi-weekly, starting from two weeks after emergence. All data were subjected to analysis of variance followed by mean separation using the new Duncan's multiple-range test. Nematode data were transformed using ln (x+1) before analysis to normalise the distribution. Ratios and indices of nematode communities were also computed. The ratio of bacterivore-to-plant-parasitic nematodes was calculated as bacterivore ÷ (bacterivore + plant-parasite), while the fungivore-to-bacterivore ratio was calculated as fungivores ÷ (fungivore + bacterivore). The maturity index for plant-parasitic nematodes (PPI) and maturity index (MI) for free-living and plant-parasitic nematodes (MI) were calculated as $(v_i \times f_i)/n$, where v_i = the colonizer-persister (c-p) value assigned to the family, f_i = the frequency of family i in a sample, and n = total numbers of individual in the sample (Bongers *et al*., 1997).

RESULTS

Nineteen nematode species (11 plant-parasitic and eight free-living) were encountered at pre-planting and harvest from soil in Ayetoro and Abeokuta soybean field (Table 1). Five trophic groups [bacterivores, fungivores, omnivores, plant-parasitic nematodes (herbivores) and predators] were delineated. The plant-parasitic trophic group belonged to the order Tylenchida which comprised of the families 1) Hoplolaimidae with genera *Hoplolaimus*, *Scutelonema* and *Helicotylenchus*, 2) Longidoridae with genera *Longidorus* and *Xiphinema*, 3) Nacobbidae Genus: *Rotylenchulus* 4) Meloidogynidae Genus: *Meloidogyne* 5) Pratylenchidae Genus: *Pratylenchus* 6) Hemicycliophoridae Genus: *Hemicycliophora* 7) Criconematidae Genus: *Criconemella* 8)

Table 1: Occurrence and Distribution of Nematodes at Pre-planting and Harvest on Abeokuta and Ayetoro Soybean Fields.

Trophic Group	Order	Family	Genera	Location	
				Abeokuta	Ayetoro
Plant-parasite	Tylenchida	*Hoplolaimidae*	*Hoplolaimus*	-	+
			Scutellonema	+	+
			Helicotylenchus	+	+
		Nacobbidae	*Rotylenchulus*	+	+
		Meloidogynidae	*Meloidogyne*	+	+
		Pratylenchidae	*Pratylenchus*	+	+
		Hemicycliophoridae	*Hemicycliophora*	+	-
		Criconematidae	*Criconemella*	+	+
		Longidoridae	*Longidorus*	+	+
			Xiphinema	+	-
		Belonolaimidae	*Belonolaimus*	+	+
Bacterivores	Monhysterida	*Monhysteridae*	*Monhystera*	+	+
		Alaimidae	*Alaimus*	+	+
		Rhabditidae	*Rhabditis*	+	+
Fungivores	Tylenchida	*Aphelenchoidae*	*Aphelenchoides*	+	+
		Aphelenchidae	*Aphelenchus*	+	-
		Tylenchidae	*Tylenchus*	+	+
Omnivores	Diplogasterida	*Diplogasteridae*	*Diplogaster*	+	+
Predators	Mononchida	*Mononchidae*	*Mononchus*	+	-

+ indicates presence; - indicates absence of the nematode

Belonolaimidae Genus: *Belonolaimus*. *Xiphinema* and *Hemicycliophora* species were found in Ayetoro plots just as *Hoplolaim=us* spp. was not detected in Abeokuta (Table 1). Population densities of all genera of plant-parasitic nematodes were suppressed in the plots treated with organic fertilisers; this was in disparity with the control and the NPK-treated plots which recorded increase in the population densities of plant-parasitic nematodes in both fields. Suppressive effect on plant-parasitic nematode population density was highest (56.9% and 39.2%) on Sunshine fertilizer-amended plots, corresponding with the least (108 and 291) population of plant-parasitic nematode detected in Abeokuta and Ayetoro respectively (Table 2). *Pratylenchus* was the most frequently encountered among the 11 plant-parasitic nematode genera identified, followed by *Helicotylenchus* spp. which were specifically prevalent in unamended plots as well as the Neem and Gateway amended plots compared with Sunshine organic fertilisers treated plots (Table 2).

The bacterivore trophic consisted of the order Monhysterida; families Monhysteridae, Alaimidae and Rhabditidae in the Genera *Monhystera*, *Alaimus* and *Rhabditids*, respectively. The population density of bacteria-feeding nematodes increased on Ayetoro and Abeokuta fields. Abeokuta recorded greater ($P < 0.05$) population of bacterivores in Neem and Sunshine amended plots. Among the bacterivore trophic group, the genus *Rhabditids* was most prevalent accounting for the highest detected genus in all plots at both sampling. Consistent population of *Alaimus* spp. was also detected at NPK-treated plots in Ayetoro. Other genus of this trophic group detected was *Monhystera* spp. and *Alaimus* spp. *Rhabditids* species maintained the highest ($P < 0.05$) population density detected in Abeokuta contributing about 64% of the final population and 58% of the initial population (Table 2). The Sunshine fertiliser treated plots recorded the highest (146.3%) percentage increase of bacterivores detected in Ayetoro. A similar trend was observed in the Gateway and NPK treated plots and unamended control with 137.5%, 90% and 127% respectively (Table 2).

The fungivore trophic group constituted of the order Tylenchida; families Aphelenchoidae, Aphelenchidae and Tylenchidae while *Aphelenchoides*, *Aphelenchus* and *Tylenchus* were the corresponding genera respectively (Table 1). All three fungi-feeders were present in Abeokuta, while *Tylenchus* and *Aphelenchoides* alone were encountered in Ayetoro. On all plots amended with organic fertilisers in Ayetoro, fungivorous nematodes population density increased whereas the population density reduced in NPK and unamended (control) plots. By contrast population density of fungivorous nematodes increased across organic fertiliser amended, NPK and unamended plots in Abeokuta (Table 2). Total population density of fungivores in Neem (203) and Sunshine (194) amended plots were significantly higher ($P < 0.05$) than control plots (146) at harvest in Ayetoro (Table 2). Population densities did not however differ in all plots in Abeokuta. The root fungal feeder; *Tylenchus* spp. was most prevalent comprised of the order Diplogasterida with

Table 2: Effect of Organic Fertilisers on Number of Nematodes in Various Trophic Groups of Soybean Fields in 2013

	Ayetoro			Abeokuta		
	Initial	Final	%Change	Initial	Final	%Change
	Plant-Parasitic Nematodes					
Neem	459.3c	292.1d	-36.39	215.9b	211.0bc	-2.3
Gateway	540.5ab	355.9c	-34.16	259.0ab	130.8dc	-49.5
Sunshine	478.4bc	291.0d	-39.17	250.8ab	108.0d	-56.9
NPK	428.6c	546.0b	27.38	243.5ab	408.0a	67.6
Control	564.4a	778.5a	37.94	258.0ab	322.0a	19.6
	Bacteria-Feeding Nematodes					
Neem	114.8a	190.4ab	65.91	84.8a	155.5a	83.2
Gateway	83.5ab	198.4ab	137.58	53.6ab	99.3ab	85.06
Sunshine	89.6ab	220.8a	146.31	85.5a	149.1a	74.42
NPK	96.5ab	183.4ab	90.03	37.6b	88.9b	136.20
Control	61.38b	131.6b	114.45	50.8ab	85.1b	67.74
	Fungi-Feeding Nematodes					
Neem	118.3bc	202.5a	71.25	140.0a	256.5ab	83.2
Gateway	139.3ab	155.4bc	11.58	157.0a	283.9a	80.8
Sunshine	77.5c	193.8ab	150.00	141.0a	234.6ab	66.4
NPK	170.5a	170.0abc	-0.29	96.75.0a	207.4b	114.4
Control	180.5a	146.3c	-18.98	138.4a	230.3ab	66.2
	Omnivores Nematodes					
Neem	18.8ab	49.3abc	162.7	15.4a	71.2a	363.1
Gateway	34.6a	73.4a	111.9	25.4a	78.4a	208.8
Sunshine	18.8ab	57.0ab	204.0	31.8a	64.1a	102.0
NPK	10.0b	43.3bc	332.5	27.0a	53.8a	99.1
Control	32.3a	25.8c	-20.2	20.9a	65.5a	213.7
	Predatory Nematodes					
Neem	0a	0a	0	25.5a	61.3a	220.2
Gateway	0a	0a	0	12.9a	45.4a	252.3
Sunshine	0a	0a	0	15.5a	45.4a	192.8
NPK	0a	0a	0	26.3a	44.0a	67.6
Control	0a	0a	0	18.0a	52.9a	193.8
	Total Nematodes					
Neem	711.0ab	734.3c	3.3	475.3a	787.6ab	65.7
Gateway	797.9a	78c	-1.9	507.9a	655.1c	29.0
Sunshine	664.3b	762.6c	14.8	524.5a	625.9c	19.3
NPK	705.6ab	942.6b	33.6	431.1a	882.9aa	104.8
Control	838.5a	1090.1a	30.0	550.1a	729.8bc	32.7

% Change: [(Final population – Initial population)/Initial population /population × 100] Means with same alphabets are not significantly different from one another along column. (-) sign shows percentage reduction.

Aphelenchoides was also detected in both fields. The omnivorous trophic group although a consistent population of

Diplogasteridae and *Diplogaster* being the only family and genus respectively, detected on both fields. Similarly, predator trophic group consist of order Mononchida; family Mononchidae and genus *Mononchus* which was only detected in Abeokuta field (Table 1). Population density of omnivorous nematodes increased in all plots of both fields except in unamended plots of Ayetoro. Omnivores detected in Gateway amended plots was significantly ($P<0.05$) greater than NPK and unamended control plots whereas it was statistically similar to Neem and Sunshine plots. No significant differences in the population densities observed across plots in Ayetoro and Abeokuta. The soil population density of predatory nematodes was increased. However, there were no significant differences in organic, NPK and unamended control. Predatory nematodes were not detected in Ayetoro.

The BP ratio increased at harvest for both fields, though the BP ratio was greater ($p<0.05$) at Ayetoro than at Abeokuta at harvest. The FB ratio on the other hand declined (Table 3). The FB ratio in Abeokuta were similar at initial sampling but varied at harvest with FB ratio of the control plot significantly ($P < 0.05$) highest compared to fertiliser treated plots (Table 3); the high FB ratio of the control plots indicated low nutrient enrichment. The PPI varied through time at both sites with greatest PPI (0.41 – 0.41) recorded in plots treated with Sunshine fertiliser. The MI decreased at harvest for both sites, MI values (0.72 – 0.76 and 0.71 and 0.85) of all organic fertiliser amended plots were significantly higher ($P < 0.05$) than the control plots (0.52 – 0.67) of Ayetoro and Abeokuta respectively (Table 3).

Table 3: Organic Fertilisers Effect on Nematode Ratios and Indices on Two Soybean Fields

	Initial				Final			
	MI	PPI	FB Ratio	BP Ratio	MI	PPI	FB Ratio	BP Ratio
Ayetoro								
Neem	0.80ab	0.43ab	0.50cd	0.20a	0.76a	0.41a	0.52a	0.39a
Gateway	0.71ab	0.38ab	0.62bc	0.13bc	0.72a	0.39a	0.44a	0.36a
Sunshine	0.85a	0.46a	0.48d	0.15abc	0.74a	0.40a	0.47a	0.43a
NPK	0.79ab	0.43ab	0.64b	0.18ab	0.60b	0.32b	0.49a	0.25b
Control	0.68b	0.36b	0.76a	0.10c	0.52b	0.28b	0.51a	0.15c
Abeokuta	1.87ab	0.65ab	0.6278a	0.20a	0.85a	0.43ab	0.51cd	0.28a
Gateway	1.73ab	0.60ab	0.7352a	0.13bc	0.71a	0.38ab	0.62bc	0.18ab
Sunshine	1.69ab	0.59ab	0.6191a	0.15abc	0.85a	0.46a	0.47d	0.26ab
NPK	2.04a	0.71a	0.6278a	0.19ab	0.80a	0.43ab	0.63b	0.14b
Control	1.57b	0.55b	0.7478a	0.10c	0.67c	0.36b	0.76a	0.14b

Means with same alphabets are not significantly different from one another along column MI: Maturity Index PPI: Plant-Parasite Index, FB Ratio: Fungi-to-Bacteria Ratio, BP Ratio: Bacteria-to-Plant-parasite Ratio .

Plant heights (74.8), number of leaves (56) and stem girths (0.59) of the Neem fertiliser-treated plots were significantly ($P < 0.05$) greater than all other treatments through the growing season in Abeokuta except stem girth at two weeks after emergence (WAE) where there were no significant difference in the stem girths. Similarly, plant heights of Gateway (27, 67.3) and Sunshine (26.5, 59.7) amended plant at two and six WAE were significantly ($P < 0.05$) greater than NPK (24.6, 49.6) and unamended plants (23.1, 52.3) (Table 3). At Ayetoro however, plant height (70.2 – 75.6) of organic amended plants at six WAE were significantly taller ($P < 0.05$) than unamended (control) plants (65.1). Statistically lesser ($P < 0.05$) number of leaves was produced by the control (15.6) and Sunshine (20.4) amended plants at four WAE in Abeokuta. Neem amended plant however produced significantly ($P < 0.05$) fattest stem girth (0.59) at two WAE (Table 4). Grain yield obtained from the organic fertiliser amended plots were greater ($P < 0.05$) than that obtained from control plots as well as the NPK treated plots (Table 5). Neem treated plants produced greater pod weights (20 and 19 g) and grain weight per plant (11.6 and 12.9 g) for both Ayetoro and Abeokuta fields respectively, while unamended plants produced least pod weight (9 and 9.6 g) and grain weight (6.8 and 5.2 g) for Ayetoro and Abeokuta, respectively (Table 5).

Table 4: Effect of Organic Fertilisers on Growth Performance of *Meloidogyne* spp. Susceptible Soybean Variety, TGx 1019-2EN Two (2) Fields in Ogun State

	Plant Height (cm)			No of Leaves			Stem Girth (cm)		
	WAE			WAE			WAE		
	2	4	6	2	4	6	2	4	6
Ayetoro									
Neem	36a	49.4a	70.2a	19.6a	43a	70.8a	0.40a	0.57a	0.66a
Gateway	35.4a	54.3a	75.6a	17.3a	41a	69.3a	0.37ab	0.55a	0.65a
Sunshine	36.9a	50.5a	72.7a	17.1a	36.3ab	62.5a	0.36b	0.56a	0.67a
NPK	33.9a	51.4a	74a	18.8a	33.1b	68.3a	0.36b	0.58a	0.65a
Control	35.9a	50.4a	65.1b	17.1a	40.9a	60.8a	0.33b	0.54a	0.65a
Abeokuta									
Neem	29.9a	39.4a	74.8a	14a	26.2a	56.4a	0.39a	0.59a	0.93a
Gateway	27b	34.3b	67.3b	12.5b	21b	43.8b	0.36a	0.43b	0.50b
Sunshine	26.5b	32.2b	59.7c	12.2b	20.4b	37.4c	1.71a	0.47b	0.51b
NPK	24.6c	28.8c	49.6d	11.2bc	20.2b	32.8cd	0.34a	0.42b	0.50b
Control	23.1c	32.2b	52.3d	10.5c	15.6c	28.9d	0.32a	0.42b	0.50b

Means with same alphabets are not significantly different from one another along column.

WAE: Weeks after Emergence

Table 5: Effect of Organic Fertilisers on Grain Production of *Meloidogyne* spp. Susceptible Soybean Variety, TGx 1019-2EN in Two Fields in Ogun State

		No of Pods	Pod Weight (g)	No of Grains	Grain Weight (g)
Ayetoro	Neem	60.8a	20.1a	107.1ab	11.6a
	Gateway	61.8a	18.0a	112.4a	11.3a
	Sunshine	45.9bc	14.1b	79.5cd	8.6ab
	NPK	49.9ab	13.1b	89.7bc	8.1b
	Control	34.9c	9.0c	59.9d	6.8b
Abeokuta	Neem	60.3a	18.6a	112.0a	12.9a
	Gateway	50.8b	15.6a	95.4b	9.1b
	Sunshine	53.7ab	15.2a	95.8b	9.3b
	NPK	40.0c	10.2b	74.0c	6.0c
	Control	33.9c	9.6b	67.7c	5.2c

Means with same alphabets are not significantly different from one another along column.

DISCUSSION

Amendment of soil with different organic fertilisers influenced the abundance and structure of nematode communities and this resulted in improved yield of the soybean. Previous studies reported changes in the occurrence and abundance of nematode trophic groups as related to soil management practices and fertilisation especially organic amendments (Freckman 1988; Freckman and Ettema 1993; Renčo *et al*., 2010). Suppression in the population density of plant-parasitic nematode when organic amendments were incorporated into the soil has been documented (Stirling, 1991; McSorley and Federick 1999; Renčo *et al*., 2010).

Findings in this present work showed significant reduction in number of plant-parasitic nematodes in comparison to control. The three organic fertilisers applied to soil suppressed plant-parasitic nematodes, this is consistent with the findings of Atungwu *et al*., 2012 who reported that soil amendments with different neem-based organic fertiliser caused significant reduction in the population of root-knot nematodes and their damage in soybean.

Suppressive effect of organic amendments on plant-parasitic population densities generally resulted from different contributory mechanisms (Stirling, 1991). The accumulation of nematode-toxic nitrogenous compounds during organic matter decomposition was reported to be involved in suppressing plant-parasitic nematode population in amended soil (Rodriguez-Kabana, 1986). Enhancement of microbial activities of plant-parasitic nematode competitors, antagonists and parasites on the feeding substrate provided by organic matter into the soil could cause decrease in plant-parasitic nematode population (Rodriguez-Kabana, 1986).

Organic fertiliser amendments expressed increasing effect on free-living nematodes while it suppressed the population density of plant-parasitic nematodes. All three organic fertilisers stimulated the population of bacteria-feeding, fungi-feeding, omnivorous, and predatory nematodes. The different responses of bacteria-feeding and fungi feeding nematodes could be hinged on diverse richness of bacterial and fungal food substrate as previous studies attributed the effect of organic amendments on bacteria and fungi-feeding nematodes to increased food availability (Freckman 1988; Ferris *et al.*, 1996, McSorley and Frederick 1999)

Trends of the BP and FB ratio of organic fertiliser amended plots of both fields showed bacterial predominance, probably reflecting good soil fertility (Popovici and Ciobana, 2000). Following Bongers and Ferris (1999), we can infer that organic matter availability and stimulated microbial activity changed ratio of persister and opportunist nematodes. Greater MI values observed on the organic fertiliser amended plots reflected dissimilar influence of amendments which is contrary to the results of Yeates (1994) who observed similar proportion of free-living nematodes in the CP 1, CP 4, and CP 5 groups in fields managed organically and inorganically.

CONCLUSION

The three organic fertilisers namely Gateway, Sunshine and Neem amendments increased the population of free-living nematodes and suppressed plant-parasitic nematodes. Neem organic fertiliser was superior to Gateway and Sunshine as it improved soybean yield the most

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