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Comparative Effect of *Rotylenchulus reniformis* and *Meloidogyne incognita* on the Productivity of okra in Nigeria

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Abstract

Okra has risen in importance from being the fifth popularly produced vegetable to the second in the last few years in Nigeria. This study therefore evaluated the impact of growing okra in soils infested with *Rotylenchulus reniformis* and *Meloidogyne incognita*. A pot experiment was conducted in the screenhouse with three popular okra cultivars (NH 47-4, LD66-1 and Clemson spineless) inoculated with either *R. reniformis* or *M. incognita* and compared to uninoculated plants. The experiment was arranged in a completely randomized design with five replicates. The field trial was conducted using one cultivar, Clemson spineless and the same treatments as the pot trial laid out in a randomised complete block design with four replications. Data were collected on number of leaves, leaf area, plant height, number of fruits and fruit weight and submitted for analysis of variance. Significant reduction in number of leaves and plant height was observed in inoculated compared to uninoculated plants. Inoculated plant produced smaller and fewer fruits in comparison to the control. Yield reduction in pots was 31-72% in pot experiments with *R. reniformis* and 51-76% in pots with *M. incognita*. Yield of Clemson spineless in the field was reduced by 36% and 40% by *M. incognita* and *R. reniformis* respectively. The reniform nematode has gone beyond being a potential pest of vegetable crops such as okra in Nigeria to being an actual pest that requires serious management interventions.

Key words: Abelmoscus, damage index, reniform nematode, endoparasites, yield.

INTRODUCTION

Okra (*Abelmoschus esclentus* (L) Moench) is one of the most widely known and utilized species of the family Malvaceae (Naveed *et al*., 2009) and an economically important vegetable crop grown in tropical and subtropical parts of the world (Oyelade *et al*., 2003). It ranks first before other vegetable crops apart from tomato, is consumed in almost every household in Nigeria (Babatunde *et al*., 2007) and is found in almost every market in Nigeria (Atiri *et al*., 2000). Okra used to rank fourth or fifth in importance among vegetable crops, it is now however, ranking as a very close second to tomato as the most important vegetable crop in Nigeria (FAOSTAT, 2016). Okra production constitutes about 4.6 percent of the total staple food production in Nigeria (CBN, 2016). Its cultivation occupies 1.09 million hectares in Nigeria which produces 2 million tonnes almost as high as tomatoes at 2.1 million tonnes compared to pepper at 739 thousand tonnes and onions at 235 thousand tonnes (FAOSTAT, 2016). The crop contributes immensely to the economic status of farmers especially those engaged in large scale production of the crop in dry season, and can be regarded as a food security crop as many families plant okra as a garden crop

Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds (Mihretu *et al*., 2014). The entire plant is edible and is used to make several food preparations (Maramag, 2013). The immature fruits of okra consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled (Ndunguru and Rajabu, 2004) and the seeds contain 20-40% oil. The fruit offers mucilaginous consistency after cooking. Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander. The mucilage of okra binds cholesterol and bile acid carrying toxins (Jenkins *et al*., 2006). Yield limiting factors of okra include soil fertility, insect pests, diseases and nematodes (Mukhtar *et al*., 2017).

Plant-parasitic nematodes are often associated with soil and roots and produce little typical symptoms on aerial parts of host plants. Economic losses on many crops have not been very well established especially in the tropics. However, earlier estimates as well as recent, detailed inventory indicate an overall crop loss of about 20% despite control measures (Abawi and Widmer, 2000); (Dhaliwal *et al*., 2012). Local damage due to heavy infestations by certain species is often higher. Among plant-parasitic nematodes, the root-knot nematode alone or in combination of other pathogens, is a very destructive one and tremendously reduces both quantity and quality of vegetables (Abawi and Widmer, 2000; Sikora and Fernandez, 2005). Vegetable crops, due to multiple cropping pattern, good moisture level and continued presence of host, are the worst sufferers from the invasion of root-knot nematodes in the tropics and subtropics. Okra is known to be highly susceptible to root-knot nematodes and infected plants are stunted, exhibiting signs of nutrient deficiency and characteristic large swellings on both primary and secondary roots (Thies *et al*., 2010). Okra is reported to suffer more than 90% yield loss when grown in fields infested with 3 - 4 *Meloidogyne incognita* per gram of soil (Amer-Zareen *et al*., 2001). Yield increases on okra, tomato, and lettuce of 19, 15, and 57% were obtained with treatment of granular nematicides, respectively on *Rotylenchulus reniformis* infested soil (Sikora and Fernandez, 2005). *R. reniformis* has been reported to be associated with various crops (Adegbite *et al*., 2006; Daramola and Afolami, 2014; Olabiyi *et al*., 2009) in Nigeria but has not been clearly connected to any quantitative loss of yield in Nigeria. The aim of this study was to assess the effect of the reniform and root-knot nematodes associated with the infection of okra.

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MATERIALS AND METHODS

Experimental sites:

The field site was identified during a related survey of plant-parasitic nematodes associated with vegetable crops. The specific field was located at Ewekoro (Latitude: 6° 55' **59.99**" N. Longitude: 3° 12' **60.00**" E.) near Abeokuta in Ogun state, Nigeria. The screenhouse experiment was conducted in the facility of the Department of Crop Protection and Environmental Biology, University of Ibadan.

Source of seeds and inoculum:

Three cultivars of okra, NH47-4, LD88-1, and Clemson spineless 40 (hereafter referred to as Clemson), were collected from the Institute of Agricultural Research and Training in Ibadan, Nigeria. Inoculum of *Rotylenchulus reniformis* was from the naturally infested plots while *Meloidogyne incognita* inoculum was obtained from galled tomato roots cultured in the Department of Crop Protection and Environmental Biology, University of Ibadan. The culture originated from a single egg mass of identified *M. incognita*.

Nematode culture establishment:

Soil infested with the reniform nematode was collected in bags from the field site in Ewekoro where they occurred naturally and transported to the Department. The soil was filled into twelve 25 cm diameter pots containing 4 kg of soil. Susceptible Roma tomato variety was planted in the pots and maintained for 8 weeks. The tomato shoots were cut off and the pots upturned over a polyethylene sheet. The roots were then gently separated from soil and washed with water under running tap. Few galls present in the roots were cut out and removed from the inoculum, then roots were chopped into 1 cm pieces. The roots were examined under stereo-microscope ×40 to confirm the presence of egg masses of the reniform nematode. Measures of 5 g of root were placed in water in a petri dish for observation. Root-knot nematode cultures used for this study were already established on tomato plants in pot cultures. Tomato was also planted in the naturally infested field to increase nematode populations and the infected roots were used to prepare inoculum for the field.

Extraction and estimation of inoculum:

The pot experiment was inoculated with extracted nematodes in water suspension while the field experiment was inoculated with infected roots. Eggs of *Meloidogyne incognita* and *Rotylenchulus reniformis* were extracted separately from infected roots using the sodium hypoclorite (NaOCl) method (Hussey and Barker, 1973) (Walters *et al*., 1993). Washed and chopped infected roots of each nematode was placed in a jar and 0.5% NaOCl was added to just cover the roots in the jar. The jar was tightly covered and agitated for 4 min. After which the contents were emptied over a stack of three sieves 150, 75, 25 µm to separate the root fragments and debris from the eggs. Egg were collected in 25 µm sieves, thoroughly rinsed and washed out into beakers using a wash bottle.

A syringe was used to take 1 ml from the extract into a counting slide from which eggs were counted while observing under ×10 of a microscope. An average of three counts was taken as the number of nematodes per ml of each extract. The egg suspension of the reniform was incubated in distilled water for 15 d at 27±1 ^{o}C to allow for development to the J4 stage according to (Ganji *et al*., 2013). Root-knot nematode eggs were incubated for 5 days to allow for J2 emergence. These juvenile stages served as inoculum for the respective nematodes. Inoculum concentration of both nematodes was 1 nematode/1cm^3 soil volume.

Galled roots from pot cultures and *R. reniformis*-infected roots from the experimental site were separately washed and chopped into 1 -2 cm pieces. Three 5 g samples were weighed out and the nematodes extracted as above. The average number of nematodes per gram was used to estimate the root weight that would contain the required amount of inoculum for field inoculations. For root-knot nematode, 1 g of galled roots contained 680 eggs while 1 g reniform infected roots contained 320 eggs.

Screenhouse experiment:

The soil used for the pot experiment was steam sterilized in a soil sterilizer for 3 hours at 90^{o}C after which it was filled into 25 cm diameter plastic pots. Three seeds each of the okra varieties NH47-4, Clemson spineless 40, and LD88-1 were planted per pot and thinned to one vigorous plant per pot. Pots were arranged in a randomized complete block design with five replications, three okra cultivars and three nematode treatments. Plants to receive *R. reniformis* and *M. incognita* inoculum were inoculated with 5000 forth stage (J4) and second stage (J2) juveniles respectively. Inoculum was delivered in a water suspension to the exposed roots of the plants using a syringe. The point of inoculation were covered over with soil after inoculation. Uninoculated plants served as control. Plants were irrigated at two day intervals and maintained at 28±2^{o}C, 75% relative humidity and 12 h day light.

Field trials:

Field trials were located at Ewekoro and the specific farmer-owned field had been consistently cropped with tomato, okra and other vegetables. Soil samples were taken systematically per 20 m^2 plots and taken to the laboratory at the Department for nematode extraction. Extraction from soil was carried using the extraction tray the method (Coyne *et al*., 2007). Number of *R. reniformis* per 200 cm^3 was 236 (1.68 *R. reniformis*/cm^3 of soil) while root-knot nematode was 4/200 cm^3 (0.02 *Meloidogyne*/ cm^3 of soil) and was considered negligible. The selected land was divided into three blocks and two of the blocks (block 1 and 2) were treated with nematicide (Carbofuran 3G) one month before planting, while tomatoes were planted in the third block (block 3) to build up nematode populations. Block 1 represented the control and was left uninoculated; block 2 was inoculated with 5000 *M. incognita* per plant two weeks after planting; block 3 was inoculated with an additional 2000 *R. reniformis* per plant to what was naturally contained in the soil. The experiment was a laid out in a split-plot design with three nematode treatments and four replications.

One okra variety was selected for this study, Clemson spineless 40, and planted in plots within each block replicated four times. Seeds of okra were planted at a spacing of 75 × 50 cm with 9 plants per plot (1× 1.5 m). Spacing between plots with 50 cm and 1 m between blocks. Individual plants were inoculated with infected roots containing the required amount of inoculum two weeks after planting. There were two applications of contact insecticide at 4 and 7 weeks after planting against insect pests and to prevent virus transmission and plots were manually kept weed-free.

Data collection and analysis:

Data on plant height and leaf area (using leaf area meter Li-3000, USA) were collected at two week intervals post inoculation. Number of days to flowering was noted for each treatment. The pot experiment was terminated 10 weeks after inoculation while the field experiment was terminated 12 weeks after inoculation. three plants in the inner rows per plot were selected for data collection per plot. Number and weight of fruits were taken at four day intervals from the appearance of the first fruits. Percentage reduction in fruit yield was calculated over the control.

At the end of each experiment plants were cut at the soil level and shoot separated from the roots and weighed separately. Galling index was assessed on a scale of 1-5 where 1= no damage, 2= 1-15%, 3 = 16-30%, 4 = 31-60%, 5 = >60%. Damage rating for the reniform nematode was conducted by counting the number of egg masses in 5 g of chopped and mixed roots using the modified scale of (McCarty *et al*., 2012) where 1= no egg mass and 5 = 10 egg masses/g. For pot experiments, soil in each pot was thoroughly mixed and 200 cm^3 was measured out for extraction using the extraction tray method (Coyne *et al*., 2007). For field plots, plants were dug up with a shovel and soil samples were taken from the rhizosphere soil at the base of each sampled plant per plot, then bulked to represent the plot. The soil was thoroughly mixed in the laboratory and 200 cm^3 was measured out for extraction as previously described. Eggs were extracted from harvested roots using the NaOCl method. Eggs were extracted from 10 g of roots that had been chopped (~2 cm) and thoroughly mixed to represent each plant. Total soil population was calculated based on soil volume in pot (5000 cm^3) and the total volume of soil collected from each plant before sampling. Final nematode population (Pf) was the summation of total number of eggs per plant root and total number of juveniles in soil. Reproductive factor (RF) was calculated using Pf/Pi where Pf was the final nematode population and Pi was the initial population (inoculum).

Data were processed using Microsoft Excel. Data on nematode counts were transformed using $\sqrt{x+0.5}$. Analysis of variance was performed using the Statistical analysis system (SAS) programme and significant means were separated using Fishers protected least significant difference (LSD) at $\alpha = 0.05$.

Results:

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Plants that were inoculated with either the reniform nematode (RN) (*Rotylenchulus reniformis*) or the root-knot nematode (RKN) (*Meloidogyne incognita*) in pot experiments were shorter compared to the uninoculated control okra plants in the three okra cultivars (Figure 1). The reduction in plant height was significant where root-knot nematode was concerned in the three cultivars. However, for reniform nematode the reduction in plant height was only significant for Clemson. Plant height was not significantly different between both inoculated nematodes. A similar trend was observed for the number of leaves. For okra cv NH 47-4 and LD88-1, significantly fewer leaves were produced in plants inoculated with RKN compared to those inoculated with RN or control (Figure1). In addition, for okra cv Clemson, significantly fewer leaves were observed in RN treated plants compared to the control. Clemson okra cv inoculated with both RN and RKN in the field were significantly shorter compared to those in nematicide treated field plots (control) (Figure 2). The number of leaves and leaf area observed from plants in the infested plots was not significantly different between the nematodes but where significantly lower compared with the control.

The number of days to anthesis was shorter in nematode-infected plants compared to the uninoculated control in both field and pot trials (Table 1). In pot experiments there was no significant difference in the number of days to first flower between RN and RKN-inoculated plant. Whereas, in the field experiment, there was a significant difference, with RKN-infected plant flowering earlier than RN-infected plants. The number of fruits produced and fruit yield were significantly lower in both inculated pots/plots compared to pots/plots where there were no nematodes. This translated to a percentage yield reduction of 31.8% (Clemson) to 72.5% (LD-88-1) for plants inoculated with *R. reniformis* in pot experiments, while yield reduction in field plot for Clemson was 40.6%. For root-knot nematodes, yield reduction in pots experiments were high ranging from 51.5% (NH 47-4) to 76.2% (LD-88-1) while the reduction in field plots with Clemson was 36.3%.

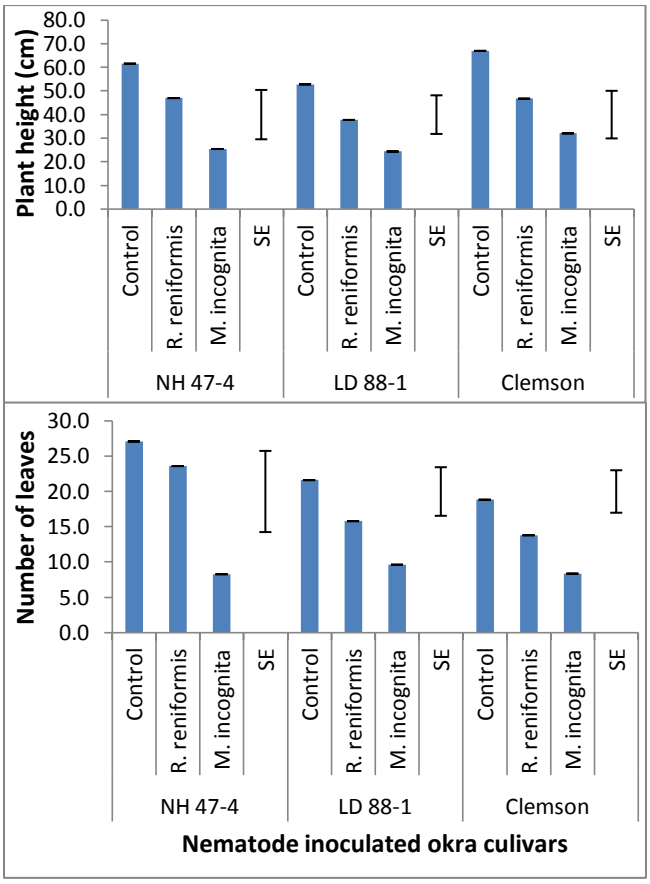

Fig. 1: Plant height (cm) and number of leaves of the three okra cultivars in pot experiments.
SE = Standard error

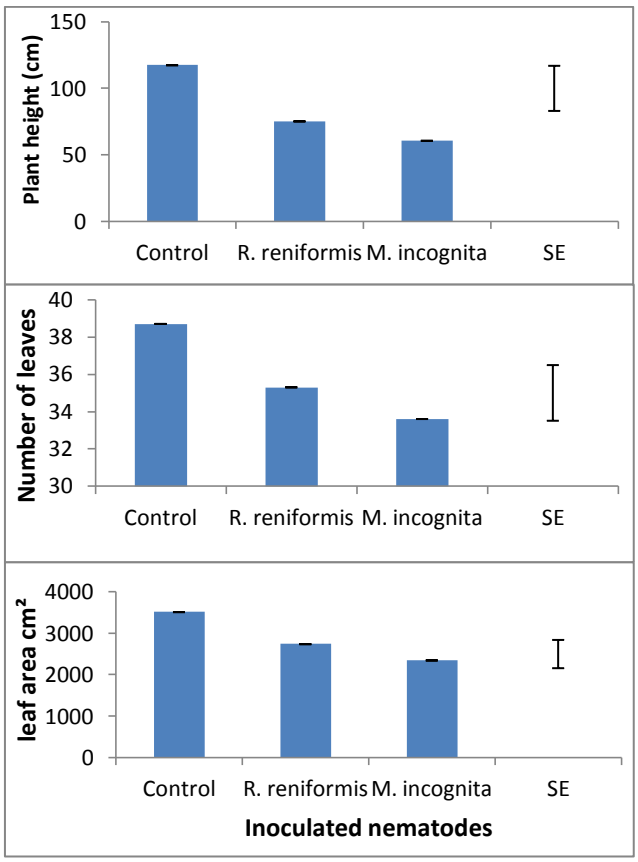

Fig. 2: Plant height, number of leaves and leaf area of Clemson spineless in field trials with *Rotylenchulus reniformis* and *Meloidogyne incognita*

In pot experiments, galling in *Meloidogyne* - inoculated okra plants was very severe at 3.7, 4.0 and 4.7 for NH 47-4, Clemson and LD88-1 respectively. The galls observed on the okra roots were large and tended to crack in a some cases. The roots of okra infected with reniform nematode appeared healthy at first glance but appeared to have less root volume (data not shown). The damage index for the plants infected with reniform nematodes was moderately high based on egg mass count per gram. The total nematode population recovered from roots and soil was higher (not significant) in RKN versus RN - infected plants. Both nematode reproduced well on the three okra cultivars although the reproductive factor on NH 47-4 was lower in RN-inoculated pots compared to RKN inoculated pots, while the reverse was the case with cv LD 88-1 and Clemson. In the field trial with Clemson, *R. reniformis* induced the highest possible damage score in okra roots of more than 10 egg masses/g while galls induced by *M. incognita* gave a mean root damage of 60% . Nematode population recovered from the plants was significantly higher where *M. incognita* was the nematode compared to where *R. reniformis* was present. Root-knot nematodes had reproductive factor if 103.9 while the reniforn nematode had an RF of 18.4. Being field plot, a few juveniles were found associated with soil and roots in the control plots and RF was not calculated for the plots.

Discussion:

Okra plants showed signs of being stunted with lower height and fewer leaves when they were challenged with either the reniform or root-knot nematode. The reduced leaf area observed in the field experiments demonstrates that the nematodes reduce both number and size of leaves. The result of which is reduced photosynthetic ability culminating in reduced ability to sequester assimilates. The process of nematode feeding on plant roots results in the reduced efficiency of roots and makes the root unable to support efficient plant growth. Galled roots have only limited ability to absorb and transport water and nutrients to the rest of the plant, severely infected plants may wilt, or may exhibit nutrient deficiency symptoms and may show nematode-induced chlorosis (Mitkowski and Abawi, 2003). The reniform nematode and root-knot nematode are associated with general poor plant performance (Bairwa and Patel, 2016a). Stunting is frequently observed on host crops grown in root-knot nematode-infested fields, and crop yields are reduced (Mitkowski and Abawi, 2003). From the results (data not shown)

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it was observed that leaves produced were not significantly different in the first three weeks of data collected after inoculation, but reduced progressively as some leaves senesced early in inoculated plants. (Koyama, 2014) demonstrated that plant parasitic nematodes are involved in the mechanism of senescence. The shedding of leaves could also be a coping mechanism for stress by the plant. Early senescence was observed by (Forti *et al*., 2015) in soybean plants infected with *Meloidogyne javanica*. There was a general reduction in the growth parameters measured for the three okra cultivars infected plants compared to uninfected plants with Clemson showing more sensitivity to the nematode than the other cultivars. Similarly, varieties of cotton expressed different host reaction to reniform and root-knot nematode infestations with sensitive varieties showing more severe symptoms as well as reduced lint production and quality (COOK *et al*., 1997) (Weaver *et al*., 2013).

Table 1: Yield parameters of three okra cultivars infected with *R. reniformis* and *M. incognita* in pot and field trials.

Parameters	Treatment	Pot			Field
		NH 47-4	LD 88-1	Clemson	Clemson
No. of days to flowering	Control	42a	45a	40a	38a
	R. reniformis	36b	38b	37b	35b
	M. incognita	35b	38b	35b	33c
	LSD	2.8	3.0	2.5	1.9
Number of fruits	Control	18.4a	19.2a	23.4a	210.6a
	R. reniformis	12.5b	14.6b	14.2b	127.8b
	M. incognita	13.8b	13.3b	14.7b	132.3b
	LSD	1.8	1.8	3.0	34.5
Fruit weight (g)	Control	167.1a	196.3a	137.2a	1324.8a
	R. reniformis	76.1b	53.9b	93.6b	787.5b
	M. incognita	81.3b	46.8b	35.8c	844.5b
	LSD	29.4	48.5	29.2	218.6
Percentage yield loss (%)	Control	0.0	0.0	0.0	0.0
	R. reniformis	54.5	72.5	31.8	40.6
	M. incognita	51.4	76.2	73.9	36.3

Values with the same letter in a column for a yield parameter are not significantly different using LSD at $p \leq 0.05$

Table 2: Damage index, total nematode populations and reproductive factor (RF)of reniform nematode (RN) (*R. reniformis*) and root-knot nematode (RKN) (*M. incognita*)on three okra cultivars in pot experiments.

Cultivars	Damage index				Total nematode population				Reproductive factor		
	Control	RN	RKN	LSD	Control	RN	RKN	LSD	RN	RKN	LSD
NH 47-4	1.0	2.3	3.7	0.8	0.7	94.6	115.3	35.1	4.5	6.7	1.9
LD 88-1	1.0	3.0	4.7	1.1	0.7	114.9	96.9	35.3	6.6	4.7	2.0
Clemson	1.0	3.5	4.0	0.9	0.7	127.3	105.6	38.9	8.1	5.9	2.4

Damage index for reniform nematode based on 1-5 scale with 1= no egg mass and 5 = 10 egg masses/g and root-knot nematode damage on a scale of 1-5 with 1= no galls and 5 > 60% galling; total nematode population is summation of nematode recovered from roots and soil transformed using $\sqrt{x+0.5}$; reproductive factor = Pf/Pi where Pf is final nematode population and Pi is initial nematode population.

Earlier flowering was observed in inoculated plants, contrary to expectation that infected plants may experience delayed flowering. This finding is supported by the discussion of (Ventura *et al*., 1981) where stressed plants flowered early as a mechanism to reduce exposure to the stress and complete the reproductive cycle. Infection with either *R. reniformis* or *M. incognita* resulted in the production of fewer and smaller fruits. This translated to significant yield reduction in the three okra cultivars evaluated. Significant yield reduction in terms of dry matter and fruit yield was observed with 6-8 egg masses per okra plant by (Agwu and Ezigbeo, 2005). Yield was reduced by up to 66.8% in the non-fumigated plots naturally infested with *R. reniformis* compared to the fumigated plots (Cook *et al*., 1997), which falls within the range of the observations in this study. Also, tobacco plants infected with the reniform nematode cause a yield loss of 31.9% which was also accompanied by loss in quality of cured tobacco leaves (Bairwa and Patel, 2016b). Yield losses ranging between 42-54. % and 42-49% for *M. incognita* and *R. reniformis*, respectively were observed in infected tomato plants (Subramaniyan *et al*., 1990). *R. reniformis* is a serious pest of a number of crop species including upland cotton, soybean, pineapple, and sweet potato (Gaur and Perry, 1991). During the 2011 growing season, cotton producers in the United States lost cotton estimated to the value of more than $90 million to *R. reniformis* infection (Blasingame and Patel, 2012). Reasons provided by (Robinson *et al*., 2005) for such huge losses include the lack of resistant varieties and the ability of *R. reniformis* to survive under adverse environmental conditions in the absence of a host

Damage caused by root knot nematode corresponded to an average of 60% root damage by galling. Cracks occurring on the large galls has an implication for secondary pathogen invasion, possibly causing further losses. This is similar to the findings of (Nwanguma, 2002) on okra, where the study demonstrated how heavy galls on okra plants led to reduced growth and yield parameters and predisposed plants to secondary invasion. The rating for reniform nematode in this study was at the maximum for the field experiment. Reniform nematodes causes severe damage to roots (Koenning *et al*., 1996). Daramola *et al*. (2015) found

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relatively high populations associated with okra fields in the same state where the field experiments for this study were conducted. This implies that nemematode is probably widespread in parts of south western Nigeria and may go unnoticed as a pest of vegetable crops due to the apparent lack of root symptoms.

Table 3: Damage index, nematode populations and reproductive factor (RF) *R. reniformis* and *M. incognita* on three okra cultivars in field experiments.

Treatments	Damage index	Nematode population in soil 250 cm^3)	Nematode population in roots (5g)	Total Nematode population	Reproductive Factor
R. reniformis	5.0	18.6	23.0	205.2	18.4
M. incognita	4.2	50.3	108.2	720.7	103.9
Control	1.1	2.3	2.2	8.9	-
LSD	3.7	17.9	41.2	263.6	24.5

Damage index for reniform nematode based on 1-5 scale with 1= no egg mass and 5 = 10 egg masses/g and root-knot nematode damage on a scale of 1-5 with 1= no galls and 5 > 60% galling; nematode population transformed using $\sqrt{x+0.5}$; total nematode population based on estimation from total root weight plus 10 kg soil; reproductive factor = Pf/Pi where Pf is final nematode population and Pi is initial nematode population.

The reproductive factor was not calculated for plants in the control plots because there was no initial inoculum to used for the calculation. A few nematodes were however, found associated with the control plants. It is expected that the reproductive factor for root-knot nematodes will be higher than that of the reniform nematode mainly due to their high fecundity of the genus. This was also reflected in the number of nematodes recovered from the two nematode treatments. Economic threshold for reniform nematode on pineapple according to Sipes and Schmitt (2000) is 310 nematodes/250 cm^3 soil reniform nematode population. Though a different crop, the population density is a similar ratio found in the field soil used for his study. This population density densities was associated with reduced growth and yield. *Meloidogyne* produce an average of 500 eggs per female (Starr, 1993) while *Rotylenchulus* produce an average of 150 eggs (Wang, 2016). The success of *Rotylechulus* is based on its ability to survive for long without a host as the juvenile stages are not known to be infective.

The three okra cultivars were sensitive to the reniform and root-knot nematode evident in the stunted growth and reduced yield. The reduced yield was a consequence of damaging population densities that reduced root efficiency. *R. reniformis* is usually found in mixed populations with *M. incognita* and the disease symptoms in such situation is often only associated with root-knot nematodes. Many authors in Nigeria have found the reniform nematode in moderate populations associated with various crops (Adegbite *et al*., 2006; Olabiyi *et al*., 2009; Afolami *et al*., 2014; Daramola *et al*., 2015) but they did not consider the nematode to be damaging. This implies that the reniform nematode can be present in damaging populations and be left undiagnosed and uncontrolled due to lack of association as a potential pest problem. This study has demonstrated that more attention needs to be paid to the reniform nematode in Nigeria and tropical Africa.

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