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Efficacy of poultry manure and biochar of cassava peels on root-gall nematode (*Meloidogyne incognita*) of okra (*Abelmoschus esculentus*) in an endemic Ultisol

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Abstract In an endemic ultisol, the efficacy of poultry manure and biochar derived from cassava peels against the root-gall nematode of okra was investigated. The Dizengoff okra variety yielded significantly ($P<0.05$) higher plant height (10.01 cm) and shoot weight (5.40 g) than Maha okra variety (8.44 cm and 5.19 g), respectively. The findings additionally demonstrated that the Maha okra variety exhibited higher quality in terms of pod weight (85.60 g) and number of pods (16.50 g), which varied considerably ($P<0.05$) from the Dizengoff okra variety's 12.06 and 75.00 g, respectively. As compared to all other soil amendments employed in this study, okra plant growth and yield parameters were boosted in plots treated with a mixture of biochar made from cassava peels and poultry manure. The best way to lessen the harm that the nematode did to the okra plant was to apply a mixture of biochar made from cassava peels and poultry manure. This mixture can be utilized as a sustainable management technique against the root-gall nematode (*Meloidogyne incognita*) in an endemic soil.

Keywords: Biochar, Cassava peels, Endemic, Poultry manure, Root-gall nematode

Introduction

Global food security is one of the most pressing challenges of the 21st century. Among the numerous factors threatening the stability and sufficiency of food supplies worldwide, the prevalence of plant-parasitic nematodes, particularly root-gall nematodes (*Meloidogyne* species), stands out as a significant barrier. These nematodes are microscopic roundworms that attack the roots of plants, causing the formation of galls, which disrupt the plant's ability to absorb water and nutrients. The impact of *Meloidogyne* species is

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especially severe in developing nations, where agriculture is often the cornerstone of both food security and the economy (Ikram *et al.,* 2024). In these regions, the damage caused by *Meloidogyne* species is a major obstacle to achieving a sufficient and stable supply of food. Smallholder farmers, who make up the majority of the agricultural workforce in many developing countries, are particularly vulnerable to these pests. The effects of nematode infestations are often exacerbated by limited access to modern agricultural technologies, including effective pest control methods. As a result, these farmers suffer substantial yield losses, which in turn contribute to food insecurity and economic instability (Khan *et al*., 2023).

A particularly troubling example of the impact of nematodes on food production can be seen in the case of okra (*Abelmoschus esculentus*), a vital crop in many tropical and subtropical regions. Research has shown that okra is highly susceptible to infection and yield loss caused by *Meloidogyne* spp. and *Pratylenchus coffeae*, another species of plant-parasitic nematode. In a study conducted by Danso and Kwoseh (2016), it was reported that the presence of these nematodes can lead to annual yield losses ranging from 22% to 99%, depending on the severity of the infestation and the environmental conditions.

Globally, plant-parasitic nematodes are responsible for an estimated $157 billion in agricultural losses each year (Singh *et al*., 2015). This staggering figure underscores the urgent need for effective and sustainable solutions to manage nematode infestations. In Nigeria, where okra is a staple food crop, the majority of yield losses are attributed to root-knot nematodes. Despite the significant impact of these pests, the issue of Phyto nematode infestations has not received the attention it deserves in Nigeria. Only a few surveys have been conducted to document the relationships between nematode infestations and agricultural crops, particularly okra. This lack of data hampers efforts to develop and implement effective management strategies.

The use of chemical nematicides has long been the most effective means of controlling root-gall nematodes. However, the detrimental effects of these chemicals on human health and the environment cannot be overlooked. Chemical nematicides are often toxic to non-target organisms, including beneficial soil microbes, insects, and even humans. Furthermore, the overuse of these chemicals can lead to the development of resistant nematode populations, rendering the chemicals less effective over time. Given these concerns, there is a growing need to find alternative forms of nematode control that are not only economically viable and as effective as synthetic nematicides but also safe for both humans and the environment (Fernandez *et al*., 2001).

One promising alternative is the use of agro-wastes and botanical nematicides—natural substances derived from plants that have nematicidal properties (Cookey *et al*., 2019). These alternatives offer the potential to manage nematode populations in a more sustainable and environmentally friendly manner. In recent years, biochar has emerged as a particularly intriguing option. Biochar is a carbon-rich material produced by the pyrolysis of biomass, such as animal and plant waste, under conditions of limited oxygen. The production of biochar involves using various feedstocks, including biogas wastes, rice stalks, maize residues, sewage waste, and municipal solid waste (Bolan *et al*., 2022).

As a soil amendment, biochar is gaining popularity for its ability to enhance agricultural productivity, improve soil biological and physicochemical properties, and mitigate negative environmental impacts (Dempster *et al*., 2012; Kamau *et al*., 2019). Biochar has been shown to reduce soil nitrogen loss and increase the efficiency of fertilizers for plant uptake (Edussuriya *et al*., 2023). In addition to improving soil fertility, biochar may also play a role in managing soil-borne pathogens, including nematodes. According to Lehmann *et al.* (2011), the addition of biochar to soils can stimulate microbial growth, which in turn may provide protection against soil pathogens through mechanisms such as competition for resources, the production of antibiotics by microbes, or direct parasitism of nematodes.

Given the potential of biochar to contribute to sustainable nematode management, this study aimed to investigate the efficacy of biochar derived from cassava peels and poultry manure in controlling *Meloidogyne incognita* in naturally contaminated soils.

Materials and methods

Experimental site

For this investigation, the planting season of 2023 was utilized. The experiment was carried out at Undergraduate Demonstrative Farms, Federal University of Technology, Owerri, Imo State, Nigeria, which is located between latitude N5° 2860" and longitude E7° 1' 60". With a relative humidity of 90%, the typical annual temperatures are 20.0°C at the lowest and 26.4°C at the highest points. Rainfall occurs there between 1500 and 2200 mm per year, from early March to October. The loamy soil had a natural infestation of *Meloidogyne* spp., or root gall nematodes (Agu, 2008).

Experimental materials

The two types of okra were acquired from AEC AGRO in Port-Harcourt, Rivers State, Nigeria; the poultry farm at Federal University of

Technology, Owerri Farms provided the soil amendment; and Egbama Ohaji, Imo State, Nigeria, supplied the cassava peels.

Land preparation and experimental design and treatments

After the experimental site was carefully cleared of all weeds, stumps, and debris, thirty-two 2.5 m by 2.5 m beds were set up. In randomized complete block design (RCBD), a 2 × 4 factorial was replicated 4 times, resulting in a total of 32 experimental plots, with 8 plots per block. With the exception of the control plots, treatments were assigned to each plot at random. Two types of okra, Maha and Dizengoff, as well as three soil amendments—biochar of cassava peels (BC), poultry manure (PM), biochar of cassava peels + poultry manure (BC+PM), and the control—were employed as treatments in this study. This resulted in eight different treatment combinations.

With a 1.0 cm furrow, the experimental site was split into four blocks. Eight plots, spaced 0.5 meters apart, were created from each block. A random combination of the eight treatments was assigned to each plot. The soil amendments were treated twice after planting, the first week after and the fourth week after, at a rate of 10 tons per hectare around the base of the plant.

Planting and spacing

In the month of October 2023, okra seeds were planted. "Maha Okra and Dizengoff Okra" okra seeds were planted with two seeds per hole, 50 cm x 50 cm planting spacing, and 2 cm planting depth. Weeding by hand was completed on schedule.

Growth and yield parameter measurement

A measuring meter tape was positioned from the base of the plant to the tip of the shoot in order to measure the height of the plant. Direct counting was used to determine how many okra leaves there were. The trifoliate leaf's leaflets were all counted. Measurements of the midrib and widest breadth were used to determine the leaf area. The leaf area of the lobed okra leaf was determined as follows: L × B × 0.62, where L is the leaf length, B is the breadth, and 0.62 is the correction factor. The leaf area of the unlobed okra leaf was determined as follows: L x B x 0.85, where L is the leaf length, B is the breadth, and 0.85 is the correction factor. This was stated by Asoegwu (1988). The number of pods produced in each plot was counted to determine the number of pods per plot. By adding up all of the pods' weight on the plot, the weight of each pod was calculated. Weighing the okra plants' above-ground sections allowed us to calculate the shoot weight, and weighing the plants' below-ground sections allowed us to calculate the root weight.

Population assay for root-gall nematode

Root-gall nematode population assays were conducted one to three times (30, 60, and 90 days) after the start of treatment. The modified Baermann approach was utilized to estimate the number of nematodes present in the soil. Soil samples that were between 0 and 30 cm deep were taken from the experimental site with the help of a soil auger. To create a single composite sample, several soil samples were bulked together. 200 g soil sub-samples were measured in order to remove nematodes. The soil samples that were measured were placed on plastic sieves lined with tissue paper and then placed on plastic trays. After that, water was cautiously poured through the opening between the tray and the sieve. Sample extracts were kept in storage for two days, during which time they were regularly monitored to make sure they did not dry up. The soil and tissue paper were disposed of, and the sieves were gently drained and taken out of the tray. After filling labelled beakers with nematode-containing water, the trays were well washed inside the beakers. Overnight, the samples were allowed to settle. Decanting the suspensions lowered their volume, and they were then gathered in a beaker for nematode evaluation. After that, the extracted suspensions were concentrated in a measuring cylinder to an exact volume of 10 milliliters. Using a pipette, aliquots were taken out of the suspensions and put into a petri plate. For the purpose of counting root gall nematodes (*Meloidogyne incognita*), this was put under a dissection stereomicroscope with under-stage illumination.

Assessment of plant root infection and data analysis

Based on the quantity of galls after harvest and an examination of each plant's individual roots, each root system was given a score (scale of 0-4) in accordance with Agu and Ogbuji (1996). The least significant difference (LSD) at the 5% probability level was used to separate the means in an analysis of variance carried out in compliance with Steel and Torrie's (1981) recommendations.

Results

At 30, 60, and 90 days following the application of soil amendments, the root-gall nematode population significantly declined (Figure 1). In comparison to the plots that received poultry manure alone (406, 324, and 290/200 g of soil) and the plots that received cassava peels alone (452, 484, and 417/200 g of soil), the combination of poultry and biochar of cassava peels was more effective in reducing the nematode population (316, 209, 154/200 g of soil). Nematode populations in the control (no treatment) plots increased steadily over 30, 60, and 90 days (689, 730 and 752/200 g of soil).

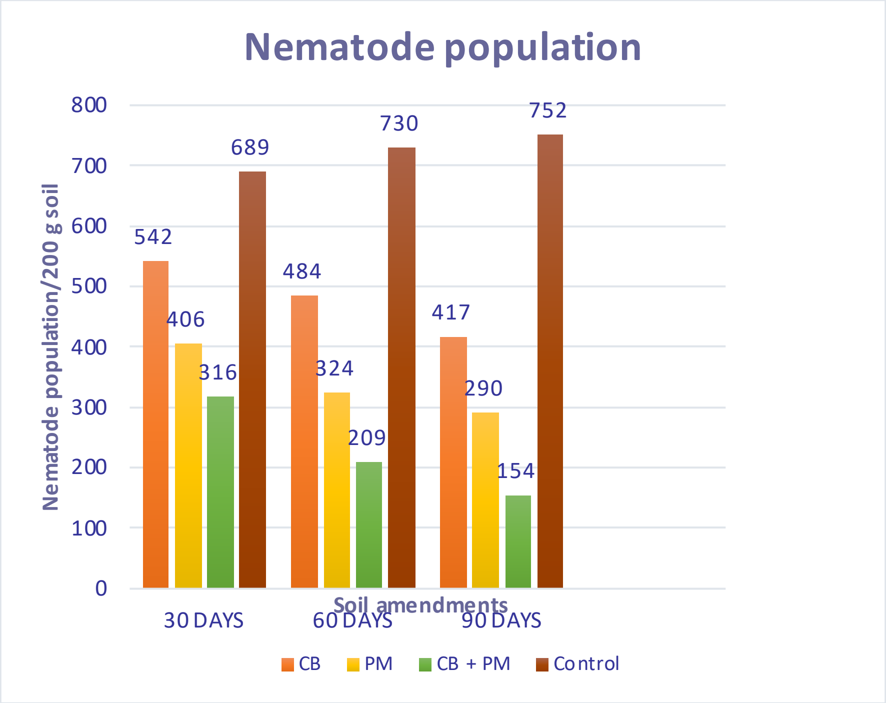

Figure 1. The impact of soil amendments on the population of nematodes 30, 60, and 90 days following the application of treatments
*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Effects of poultry manure and biochar of cassava peels on okra number of leaves as influenced by root-gall nematode infection

The application of soil amendments, varieties, or interactions did not substantially alter the quantity of leaves produced ($P > 0.05$), according to Table 1. While cultivars and interactions did not significantly impact the root-gall index, applying soil amendments had a significant impact ($P<0.05$). In contrast to the other soil amendments utilized in this study, the plots treated with a combination of poultry manure and biochar of cassava peels produced the greatest number of leaves (13.25) and were also the least galled (0.38). On the unmodified soils (control), fewer leaves (11.97) and many galled roots were observed (3.89).

Effects of poultry manure and biochar of cassava peels on plant height (cm) as influenced by root-gall nematode infection

Regarding okra plant height, soil amendments, treatments, and varieties all had a significant ($P<0.05$) effect, but their interactions failed to produce any significant effects ($P>0.05$). Moreover, the root-gall index was only considerably impacted by the application of soil amendments as shown in Table 2.

In the soil-amended plots, plant growth was higher than in the untreated plots. Plots that were altered to include both poultry manure and cassava peel biochar yielded the tallest plants (10.30 cm), which were followed by poultry manure alone (9.66 cm) and cassava peel biochar alone (9.24 cm). The control plots produced the smallest plants (7.71 cm). However, root-gall index followed a reversed trend, where the poultry manure and biochar of cassava peels mix recorded minimal gall (0.38); this was followed by poultry manure amended plots (1.38), biochar of cassava peels treated plots (2.13), while the unamended control plots had the highest root-gall index (3.89). In comparison to the Maha variety (8.44 cm), the Dizengoff variety produced the tallest plants (10.01 cm).

Table 1. Effects of poultry manure and biochar of cassava peels on okra number of leaves as influenced by root-gall nematode infection

	Number of leaves			**Root-gall index (0-4)**		
Soil Amendments	**Maha Okra**	**Dizengoff Okra**	**Mean**	**Maha Okra**	**Dizengoff Okra**	**Mean**
CB	13.96	10.09	12.46	2.00	2.25	2.13
CB + PM	14.81	11.69	13.25	0.50	0.25	0.38
PM	14.28	11.34	12.81	1.25	1.5	1.38
Control	13.29	10.65	11.97	4.00	3.75	3.89
Mean	14.08	11.16		1.94	1.94	
$LSD_{0.05}$ (Soil amendments)			4.99			0.48
LSD $_{0.05}$ (Varieties)			3.53			0.34
LSD $_{0.05}$ (Interaction)			7.06			0.69

*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Table 2. Effects of poultry manure and biochar of cassava peels on okra plant height as influenced by root-gall nematode infection

	Plant height (cm)			**Root-gall index (0-4)**		
Soil Amendments	**Maha Okra**	**Dizengoff Okra**	**Mean**	**Maha Okra**	**Dizengoff Okra**	**Mean**
CB	8.51	9.96	9.24	2.00	2.25	2.13
CB + PM	9.72	10.88	10.3	0.50	0.25	0.38
PM	8.83	10.49	9.66	1.25	1.50	1.38
Control	6.72	8.70	7.71	4.00	3.75	3.89
Mean	8.44	10.01		1.94	1.94	
$LSD_{0.05}$ (Soil amendments)			0.36			0.48
LSD $_{0.05}$ (Varieties)			0.26			0.34
LSD $_{0.05}$ (Interaction)			0.51			0.67

*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Effects of poultry manure and biochar of cassava peels on okra number of pods as influenced by root root-gall nematode infection

Application of soil amendments, varieties, and their interactions all had a significant ($P<0.05$) influence on how much okra fruit was produced (Table 3). Plots treated with a combination of poultry manure and biochar made from cassava peels yielded the most pods (18.12), followed by poultry manure alone (14.38) and biochar made solely from cassava peels (3.12). On the other hand, the least number of pods (11.50) were harvested from the untreated plots (control). Likewise, the lowest rate of nematode infection (0.38) was found in plots treated with a combination of biochar from cassava peels and poultry manure, which varied significantly from the others ($P<0.05$). The control recorded several galled roots (3.89). The Maha variety produced a greater number of pods (16.50), which was a substantial difference from the Dizengoff variety (12.06).

The interaction that resulted in the greatest number of pods (21.50) was that between the mixture of biochar from cassava peels and poultry manure and the Maha variety. This was followed by the interaction between poultry manure and the Maha variety (16.25), the interaction between biochar from cassava peels and the Maha variety (15.50), and the interaction between the control and the Dizengoff variety (10.25).

Table 3. Effects of poultry manure and biochar of cassava peels on okra number of pod as influenced by root-gall nematode infection

Soil Amendments	Number of pods Maha Okra	 Dizengoff Okra	 Mean	Root-gall index (0-4) Maha Okra	 Dizengoff Okra	 Mean
CB	15.5	10.75	13.12	2.00	2.25	2.13
CB + PM	21.5	14.75	18.12	0.50	0.25	0.38
PM	16.25	12.5	14.38	1.25	1.50	1.38
Control	12.75	10.25	11.5	4.00	3.75	3.89
Mean	12.06	16.5		1.94	1.94	
LSD$_{0.05}$ (Soil amendments)			2.43			0.48
LSD $_{0.05}$ (Varieties)			1.72			0.34
LSD $_{0.05}$ (Interaction)			3.43			0.67

*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Effects of poultry manure and biochar of biochar of cassava peels on okra root weight (g) as influenced by root-gall nematode

Application of soil amendments significantly affected ($P<0.05$) okra root weight and also root-gall index (Table 4). In comparison to the control plots, which had more severely injured roots and a higher root weight, the okra plants on the soil amendment-treated plots had considerably ($P<0.05$) fewer roots and less root-gall damage. The least root weights (0.39 g) were recorded on plots amended with a combination of poultry manure and biochar from cassava peels, while the unamended control plots recorded the highest root weight of 4.65 g. Plots treated with soil amendments also exhibited a considerably ($P<0.05$) lower root-gall index, with the least amount of nematode infection in the plots altered with poultry manure and cassava peel biochar mix. However, both root-gall index and root weight did not show any varietal differences.

Effects of poultry manure and biochar of biochar of cassava peels on okra shoot (g) as influenced by root-gall nematode

According to Table 5, the weight of okra shoots and the root-gall index of plants grown on soil-amended plots were considerably ($P<0.05$) greater and lower, respectively, than those of the control plots, which had values that were lower and higher, respectively. Plants amended with both poultry manure and biochar of cassava peels produced the highest shoot weight (6.03 g) and lowest root-gall index (0.38), followed by plots amended with poultry manure (5.64 g and 1.38) and plots amended with biochar of cassava peels alone (5.01 and 2.13). All of these, however, were different from the control plots that had the lowest shoot weight (4.51 g) and the highest root-gall index (3.89). It was shown that the Dizengoff okra variety produced a considerably greater shoot weight of 5.40 g, compared to a significantly lower shoot weight of 5.19 g produced by the Maha okra variety (P 0.05). But when poultry manure and cassava peel biochar were combined with the Dizengoff okra variety, the result was the highest shoot weight (6.10 g), which set it apart from the rest. The interaction of Maha okra variety with the control plots had the lowest shoot weight (4.18 g).

Table 4. Effects of poultry manure and biochar of biochar of cassava peels on okra root weight (g) as influenced by root-gall nematode

	Root weight			**Root-gall index (0-4)**		
Soil Amendments	**Maha Okra**	**Dizengoff Okra**	**Mean**	**Maha Okra**	**Dizengoff Okra**	**Mean**
CB	1.43	1.20	1.31	2.00	2.25	2.13
CB + PM	1.03	0.83	0.93	0.50	0.25	0.38
PM	1.35	1.90	1.63	1.25	1.50	1.38
Control	4.68	4.63	4.65	4.00	3.75	3.89
Mean	2.12	2.14		1.94	1.94	
LSD$_{0.05}$ (Soil amendments)			0.16			0.48
LSD $_{0.05}$ (Varieties)			0.11			0.34
LSD $_{0.05}$ (Interaction)			0.22			0.67

*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Table 5. Effects of poultry manure and biochar of cassava peels on okra shoot weight (g) as influenced by root-gall nematode infection

	Shoot weight (g)			**Root-gall index (0-4)**		
Soil Amendments	**Maha Okra**	**Dizengoff Okra**	**Mean**	**Maha Okra**	**Dizengoff Okra**	**Mean**
CB	4.98	5.05	5.01	2.00	2.25	2.13
CB + PM	5.95	6.10	6.03	0.50	0.25	0.38
PM	5.68	5.60	5.64	1.25	1.50	1.38
Control	4.18	4.85	4.51	4.00	3.75	3.89
Mean	5.19	5.40		1.94	1.94	
$LSD_{0.05}$ (Soil amendments)			0.21			0.48
LSD $_{0.05}$ (Varieties)			0.15			0.34
LSD $_{0.05}$ (Interaction)			0.30			0.67

*CB= Biochar of cassava peels *PM= Poultry Manure * CB+PM =Mixture of biochar of cassava peels and poultry manure

Discussion

The fact that the organic additions give soil microorganisms a source of nutrition can be used to explain the decline in nematode population after 30-, 60-, and 90-days following application. These living organisms compete with the root-gall nematodes for available nutrients as they break down the organic molecules. These root-gall nematodes may experience resource limitations as a result of this rivalry, which could eventually result in a drop in their population (Bardgett and Van Der Putten, 2014). The root-gall nematodes may be impacted by the combination of poultry manure and biochar made from cassava peels. Organic matter found in poultry manure promotes the establishment of advantageous bacteria, some of which may be antagonistic to nematodes. However, biochar has the ability to change the microbial communities and soil conditions (Jeffery *et al.*, 2017), which may lead to a decrease in nematode numbers. Through indirect methods like predation, competition, or hostility from soil microbes, these amendments, when combined, may reduce root-gall nematodes (Shi *et al.*, 2023). For nematodes and other soil organisms, compounds and secondary metabolites present in cassava peels may have allelopathic effects. The number of nematodes in the soil is reduced by these compounds because they can stop nematodes from moving, reproducing, or hatching their eggs.

The slow rate of action of the amendments (Albano *et al.*, 2023) or the damaged roots' incapacity to absorb nutrients from the soil may be the cause of the non-significant effect of the amendments on the quantity of leaves generated. The regular movement of water and nutrients through a plant's roots to its various sections is impeded by root-gall nematodes. This is consistent with research by Kantor *et al.* (2024), which found that root-gall nematodes harm crops by feeding on their roots and reducing the capacity of these crops to absorb nutrients and water. Ononuju *et al.* (2015) reported a decline in shoot growth and leaf count. Additionally, our investigation revealed that using a blend of poultry manure and cassava peel charcoal resulted in more leaves and less nematode disturbance. In instance, biochar's substantial area and permeability allow it to retain water and nutrients or to act as a home for helpful soil bacteria. These characteristics increase the crop's ability to survive pathogen-caused harm. This validates other findings that indicate various forms of biochar and poultry manure can improve the soil quality and lessen phytopathogen damage.

The nutritional and nematode-resistance qualities of the poultry manure and cassava peel biochar soil additives may have contributed to the increased plant heights seen beneath these plots. These soil amendments also served as a barrier against nematode attack. Both poultry manure and biochar of cassava peels can improve soil health and plant vigor, which may indirectly reduce the susceptibility of plants to nematode infestation This is consistent with several writers' works (Cookey *et al*., 2015; 2019).

The okra's predisposition to root-gall nematode infection may be the cause of the fewer pods observed on the unaltered control plots. Crop productivity is typically impacted by root-gall nematode attacks, which deny crops access to the nutrients they require for growth and development. This outcome is consistent with the Ononuju *et al.* (2015) findings.

Soil amendment with different biochar sources increases the activities and biomass of microbial communities and also enhances the yield of crops. Different biochar types used as soil amendment have been reported to reduce the negative effect of Phyto pathogens (Bonanomi *et al*., 2015), particularly plant parasitic nematodes (Abdelnabby *et al*., 2017). Increased number of pods and reduced nematode infection observed on the amended plots in this might be as a result of ability of the amendments to enhance the soil fertility and also inhibit the nematode from attacking the plants. The presence of macro and micronutrients for plants is increased by soil amendments because they promote the activities of beneficial soil microbes. Rillig *et al*. (2010) claimed that biochar made available enough soil nutrients (boron, molybdenum and iron) which are the principal factors for biological nitrogen fixation and nodule mass which ultimately improves the yield. Similarly, the highest number of pods and least nematode infection recorded on biochar of cassava peels and poultry manure mix treated plots might be attributable to the synergistic action of the poultry manure and biochar of cassava peels on the plant and nematode. This aligns with the conclusions made by Asif *et al.* (2017) who claimed that multiple advantage of oil cake and biochar make them essential nutrient for maintaining soil health and for managing plant nematode.

In contrast to the plots that had been improved with a blend of biochar made from cassava peel and poultry manure, which recorded the lowest root weight due to the absence of galls, the unamended control plots with the highest root weight might have been impacted by the lack of soil amendments applied to the infested soil. In a study, Nwankwo *et al.* (2016) reached a comparable conclusion. By boosting the populations of certain bacteria, actinomycetes, yeast, and fungi, the application of biochar sources induces systemic plant defense against pathogens (Elad *et al.,* 2010). Parasitic nematodes of plants have been shown to experience decrease in number when exposed to biochar sources (Zhang *et al.*, 2013).

The suppression of the nematode damage and increased shoot weight by the soil amendments applications might be a resultant effect of several mechanisms, such as enhanced nutrients solubilization and up take, which helped to enhance the plant growth and increased resilience to the stress of the soil pathogens, activation of microbes, which encourages direct attack against pathogens, or introduction defense mechanism in plant (Ntalli *et al.*, 2020).

At the end of the experiment, it was observed that plots treated with combination of poultry manure and biochar of cassava peels, poultry manure alone and also biochar of cassava peels alone were able to ameliorate the root-gall nematode infection on the okra varieties, produce higher growth and yield attributes of the okra compared to the untreated control plots.

The combination of poultry manure and biochar of cassava peels proved to be the best soil amendment both in nematode control and okra growth and yield enhancement when compared with the other soil amendments used in the study. Therefore, mixture of poultry manure and biochar of cassava peels as an ecofriendly soil amendment can be utilized to minimize the negative effect of root-gall of okra in an endemic ultisol.

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