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Evaluation of Some Natural Products for the Control of Root-Knot Nematode (*Meloidogyne* spp) Infestation on Okra (*Abelmoschus esculentus* L)

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Abstract
Field experiments were conducted at Amakama Ikputu in Umuahia South LGA, Abia State, Nigeria in 2021 and 2022 cropping seasons to evaluate the effect of some natural products (*Azadirachta indica* (Neem leaf), *Tetracarpiduim conophorum* (Wallnut leaf), *Pleurotus tuberiegium (*usu), *Alchornea cordifolia (*christmas bush leaf), Cassava peels (CP), Poultry droppings in the control of root-knot nematodes (*Meloidogyne* spp) population on the growth and yield of okra (*Abelmoschus esculentus* L. Monech). The experiments were laid in a Randomized Complete Block Design with seven treatments replicated three times including the controls. The treatments were applied at the rate of 30 grams per plant. Data were collected on plant height, number of leaves per plant, number of pods per plant, weight of pod, fresh root weight, dry shoot weight, fruit yield, number of galls and final nematode population. Data collected were subjected to analysis of variance (ANOVA) and means separated using Fishers Least Significance Difference (F-LSD) at a 5% level of probability. Okra plants treated with neem leaves (867.00) [63.00] and (900.00) [133.00] recorded the highest *Meloidogyne* spp reduction, followed closely by okra plants treated with poultry droppings (967.00) [82.00] and (900.00) [165.00] and cassava peels (800.00) [97.00] and (900.00) [169.00] while the least reduction was recorded by the controls (900.00) [418.00] and (887.00) [1000.00] in 2021 and 2022 cropping seasons respectively. In terms of fruit yield, okra plants treated with neem leaves recorded the highest fruit yield (6.60 kg/ha) (3.20 kg/ha), closely followed by the okra plants treated with poultry droppings (5.40 kg/ha) (2.60 kg/ha) and okra plants treated with cassava peels (5.40 kg/ha) (2.30 kg/ha) among others while the control plots recorded the lowest yield ((2.80 kg/ha) (2.20 kg/ha) in 2021 and 2022 cropping seasons respectively. Results obtained revealed that there were significant differences between the okra plants treated with the natural products and the controls. However, okra plants treated with neem leaves, poultry droppings and cassava peels proved to be more effective compared to the other natural products and the controls in the reduction/control of root-knot nematodes as well as an increase in the yield of okra plant.
Keywords: Okra, root-knot nematodes, natural products, and control

Introduction

Okra (*Abelmoschus esculentus* L. Monech) is a flowering plant, belonging to the family *Malvaceae* (Mallow family) (NRC, 2008), and is one of the most important vegetables widely grown in Nigeria for its tender capsules or fruits and young leaves. It is an upright plant with a hibiscus-like flower (Smith *et al.,* 2002), grown in tropical and warm temperate climates (Ijewere, 2012). According to Iyagba *et al*. (2012), okra grows best on loamy and sandy loamy soils but will produce good yields on heavier soils. It is a crop of tropical and sub-tropical climates requiring a long warm and humid growing season (Komolafe *et al.,* 2021). It is a good source of vitamins A, B complex and C, proteins and minerals for human diets (Adebisi *et al.,* 2007). The immature fresh fruits are used as vegetables in soup making (Katung *et al.,* 2000) and are regarded as an important delicacy among the numerous ethnic groups and income providers for farmers in rural areas in Nigeria (Adetula, 2010).

The production of okra is not satisfactory due to attacks of several pathogens, such as bacteria, fungi, viruses, nematodes and abiotic factors (Kamran *et al.,* 2013). Among all the factors, root-knot nematodes are considered a silent threat to vegetables because they are distributed throughout the world and attack a wide range of economically important crops (Noling, 2012). They are found to be a serious pest of okra, damaging a stand and greatly decreasing and delaying the production of pods (Bolles and Johnson, 2012). Plant-parasitic nematodes are important on vegetable crops grown in various farms or gardens. The most common destructive plant-parasitic nematodes in Nigeria include the root-

knot nematodes (*Meloidogyne* spp) which cause total failure and swelling that causes up to 27% decline in the most south-eastern and western zone of Nigeria (Egunjobi, 2014). Root-knot nematodes also interact with specific fungi and bacteria to create disease complexes (Begum *et al.,* 2012) and cause the breakdown of resistance against all pathogens, which ultimately reduces the level of tolerance in plants to environmental stress. It has been reported that the root-knot nematode is responsible for yield losses of up to 27% for okra (Anwar and McKenry, 2012). The estimated overall losses of vegetables caused by *Meloidogyne* spp. are 5%–43% (Gautam *et al.,* 2014).

Several approaches have been adopted to reduce the incidence of *Meloidogyne* spp in the soil and root of crops which include the use of natural enemies (Khan *et al.,* 2008), the use of resistant varieties (Williamson and Kumar, 2006), enhancing cultural practices (Okada and Harada, 2007) and use of synthetic nematicides (Browning *et al.,* 2006). However, Ononuju and Okoye (2003) emphasized the advantages and potential use of ingredients from higher plants in controlling plant diseases. Organic amendments have beneficial effects on the soil's nutrients, physical conditions and biological activity hence improving the health of plants and reducing the nematode's population (Oka and Yermiyahu, 2000). The study was therefore carried out to evaluate the effect of the natural products; *Azadirachta indica* (Neem leaf), *Tetracarpiduim conophorum* (Wallnut leaf), *Pleurotus tuberiegium (*usu*), Alchornea cordifolia (*christmas bush leaf), Cassava peels (CP) and Poultry droppings in the control of root-knot nematodes (*Meloidogyne* spp) population and on the growth and yield of okra (*Abelmoschus esculentus* L. Moench).

Material and Methods

Experimental site

The field experiments were carried out in a root-knot nematode infested land at Amakama Ikputu Umuahia South Local Government Area of Abia State, Nigeria.

Experimental design

The experiment was laid in Randomized Complete Block Design (RCBD) with seven treatments replicated three times

Land preparation

The area of land 11.5m x 5.6m (64.4m^2) was mapped out, cleared and ploughed after which seven beds replicated three times were made. Each bed size was 1.2m x 1.2m with spacing of 0.5 in between beds and 1.0 in between blocks. The initial nematode population was determined using the Modified Baermann Technique. N.P.K 15:15:15; fertilizer at the rate of 156kg/ha (Ijoyah and Dzer, 2012) was applied to restore lost fertility.

Planting materials

Bold seeded variety of okra that are susceptible to root-knot nematodes was obtained from the local farmers in Amakama.

Treatments sources and preparations

Cassava peels were sourced from National Root Crop Research Institute (NRCRI) Umudike, Poultry manure from University poultry farm, *Pleurotus tuberiegium* (usu) from Orieugba market in Umuahia, *Alchornea cordifolia* (Christmas bush) from native forest in Amakama, *Azadirachta indica* (Neem leaf) and *Tetracarpidium conophorum* (Walnut leaf) from Forestry Research Ahiaeke, Umudike, Abia State. The natural products were thoroughly washed to remove soil debris, air dried and blended into powder using a laboratory dry mill.

Planting of seeds: Three seeds were planted per hole at a spacing of 20cm x 20cm in each plot. The okra was pre-soaked for 6 hours before planting

Treatments application

Thirty grams (30g) of each of the natural products Neem leaf (NL) powder, Walnut leaf (WNL) powder, Christmas bush powder, Cassava peels (CP) powder, Usu powder and poultry droppings were applied respectively on the experimental unit. The control will consist of pots without treatment applications.

Data collection

The experiment was terminated at ninety (90) days after planting and data were collected on plant height, number of leaves per plant, number of pod per plant, weight of pod, fresh shoot and root weight, dry shoot weight, fruit yield, number of galls and final nematode population.

Statistical analysis

The data collected in the experiment were subjected to analysis of variance ANOVA and means were separated using Least Significant Difference (LSD) at 5% probability level.

Results

Effects of natural products on plant height, number of leaves, dry shoot weight and fresh root weight per plant of okra infested with root-knot nematodes in 2021 and 2022 cropping seasons

The effect of natural products on plant height, number of leaves, dry shoot weight and fresh root weight per plant of okra infested with root-knot nematodes in 2021 and 2022 cropping seasons were recorded in table 1. Significant differences were recorded on the plant height and dry shoot weight but not recorded on the number of leaves and fresh root weight at ($P<0.05$) in 2021 and 2022 cropping seasons. However, the natural products differed significantly on plant height with crops treated with poultry droppings (41.20cm) and (43.20cm) recording the highest plant height, followed closely by *Alchornea cordifolia* (41.00cm) and *Tetracarpidium conophorum* (40.60cm) and cassava peels (38.10cm) (37.50cm) while the least plant height were recorded by the controls (35.90cm) (29.70cm). There were no significant differences recorded on the number of leaves, dry shoot weight and fresh root weight for 2021 and 2022 cropping seasons respectively.

Effect of natural products on number of pods per plant, weight of pod and fruit yield in okra infected with root-knot nematodes in 2021 and 2022 cropping seasons

Table 2 represents the effect of natural products on number of pods per plant, weight of pod and fruit yield

in okra infected with root-knot nematodes in 2021 and 2022 cropping seasons. There were no significant differences recorded (P<0.05) among the natural products on the weight of pod and fruit yield. However, okra plants treated with *Azadirachta indica* (8.60 g) (12.00 g) recorded the highest weight of pod, followed closely by okra plants treated with cassava peels (7.40 g) and poultry droppings (10.80 g) while the least were recorded by the controls (2.90 g) (2.50 g) for 2021 and 2022 cropping seasons respectively. On fruit yield, okra plants treated with *Azadirachta indica* (6.60 kg/ha) (3.20 kg/ha), followed closely by poultry droppings (5.40 kg/ha) (2.60 kg/ha) and cassava peels (5.40 kg/ha) (2.30 kg/ha) while the lowest fruit yield were recorded by the controls (2.80 kg/ha) (2.20 kg/ha) for 2021 and 2022 cropping seasons respectively. Significant differences were recorded between the natural products and the controls (P<0.05) on the number of pod per plant, with the highest number of pods recorded by okra plants treated with *Azadirachta indica* (15.00) (8.70), closely followed by okra plants treated with poultry manure (13.00) (7.70) and cassava peels (12.30) (8.30) while the lowest number of pods were recorded by the controls (7.30) (1.70) for 2021 and 2022 cropping seasons.

Effect of natural products on final nematode population and number of galls per plant on okra infested with root-knot nematode in 2021 and 2022 cropping seasons

The effect of natural products on final nematode population and number of galls per plant on okra infested with root-knot nematode are represented in table 3 below. Significant differences were recorded among the treatments and between the natural products and the control at (P<0.05) on reduction of nematode population. The highest reduction in nematode population was recorded by *Azadirachta indica* (867.00) [63.00] and (900.00) [133.00], followed closely by poultry droppings (967.00) [82.00] and (900.00) [165.00] and cassava peels (800.00) [97.00] and (900.00) [169.00] while the lowest nematode population reduction was recorded by the controls (900.00) [418.00] and (887.00) [1000.00] in 2021 and 2022 cropping seasons respectively. On the number of galls per plant, significant difference was recorded between the natural products and the controls at (P< 0.05). the lowest number of gall was observed on okra plant treated with *Azadirachta indica* (1.00) (3.00), followed closely by plants treated with poultry droppings (1.30) (4.00), cassava peels (1.60) (4.30) with the controls (8.50) (16.70) recording the highest number of galls in 2021 and 2022 copping seasons respectively.

Discussion

The use of some natural products of plant origin in the study has proven effective in the control of root-knot nematodes in field trials. The result of the field trials conducted between 2021 and 2022 cropping seasons showed that application of the natural products to okra plant effectively reduced the population of *Meloidogyne* spp as well as increased the plant growth and yield of okra plant. All the natural products used caused a reduction in the population of *Meloidogyne* spp present. However, neem leaves, poultry droppings and cassava peels significantly performed better than the other natural products used in the experiments. Researchers revealed that chemical components (alkanoid, tannins, phenol, flavonoid, terpenoids, phenols and reducing sugar) present in *Azadirachta indica* leaf and other plant-based products are responsible for the nematicidal effect on the root-knot nematodes (Hinmikaiye *et al.,* 2020). The results obtained were in agreement with the findings of Onwu *et al*., (2014) which reported that yield of okra can be increased due to organic manure application. Soils treated with neem leaf-based compost (NBC), cassava peel based compost (CPC), saw duct based compost (SBC) and Tithonia leaf based compost (TBC) significantly reduced the population of *Meloidgyne, heterodera* and *Tylenchus* nematodes species compared with control (Olabiyi and Oladeji, 2014). Aniefiok *et al*., (2013) opined that organic manure, most especially poultry droppings could increase plant height and number of leaves in okra production. Hinmikaiye *et al.,* (2020), Nwankwo *et al.,* 2016 and Fatoki and Oyedunmade, (2001) reported that application of neem leaf extract accompanied a reduction in the nematode population in infected cowpea plant with in yield increase. Ogwudire, *et al.,* 2023, Fekrat *et al.,* 2016, Tanimola and Akonikor, 2014 and Tanimola, 2008 also reported that the high rate of development observed in poultry droppings treated in okra may be as a result of the nutrients made available to the plant by addition of poultry droppings which led to higher growth rate thereby enabled the infected plant to overcome nematode attack on cowpea. This shows that poultry droppings were readily available in the best form for easy absorption by the plant roots, hence there was a boost in the morphological growth of the plant. Also plant treated with cassava peal reduced the gall incidence and population of *Meloidogyne* spp in the field trials. This could be as a result of large amount of parasitic acid (hydrocyanide) with great concentration in the polloderm and other break down product like ammonia and toxic chemicals from microbial decomposition of cassava tuber peel which have proven to be nematoxic (Osei *et al*., 2011). The poor performance recorded in the control treatments in yield and growth parameters when compared with the treated plants could be attributed to heavy nematode infestation with heavy galls resulting in disruption in nutrient uptake. Williamson and Kumar (2007) confirmed that the nematode infection leads to wilting and stunted growth.

Conclusion

The research reveals that application of natural products (cassava peels, neem leaves and poultry droppings) was significantly effective in reducing the population of root-knot nematode on okra and also improved the growth and yield since when incorporated into the soil as organic amendment materials. The present study shows that leaves of the plant natural products; *Azadirachata indica* (neem leaves), poultry droppings

and cassava peel serves as best option in the control of *Meloidogyne* spp (root-knot nematodes) among others in okra plant. Therefore, these natural products can be used as alternatives to synthetic nematicides in the control of *Meloidogyne* spp and other plant-parasitic products affecting okra plant owing to their environmental friendliness, non-toxicity and availability in the local environment.

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Table 1: Effects of natural products on plant height, number of leaves, dry shoot weight and fresh root weight per plant of okra infested with root-knot nematodes in 2021 and 2022 cropping seasons

Natural Products	Plant height (cm)		Number of leaves per plant		Dry shoot weight per plant (g)		Fresh root weight per plant(g)	
	2021	2022	2021	2022	2021	2022	2021	2022
Cassava peel	38.1	37.5	8.3	10.3	5.4	2.3	4.9	6.9
Alchornea cordifolia	41.0	37.0	9.7	9.7	5.1	2.3	2.5	3.0
Azadirachta indica	37.1	33.0	9.3	10.8	6.6	3.2	6.8	7.7
Tetracarpidium conophorum	37.7	40.6	10.7	9.0	5.2	2.4	4.6	4.4
Poultry droppings	41.2	43.2	10.7	10.0	5.4	2.6	5.7	7.7
Pleurotus tuberiegium	38.0	30.3	10.3	9.2	5.1	1.6	3.7	4.3
Control	35.9	29.7	9.0	8.3	2.8	0.8	4.1	4.1
MEAN	**38.4**	**35.9**	**9.7**	**9.6**	**5.1**	**2.2**	**4.6**	**5.5**
$LSD_{(0.05)}$ for year	1.431		NS		0.946		NS	
$LSD_{(0.05)}$ for Treatment	2.676		NS		NS		NS	
$LSD_{(0.05)}$ for interaction	3.785		NS		NS		NS	

Table 2: Effect of natural products on number of pods per plant, weight of pod and fruit yield in okra infected with root-knot nematodes in 2021 and 2022 cropping seasons

Natural Products	Number of pod per plant		Weight of pod (g /ha)		Fruit yield (kg/ha)	
	2021	2022	2021	2022	2021	2022
Cassava peel	12.3	8.3	7.4	8.4	5.4	2.3
Alchornea cordifolia	11.7	4.0	3.1	3.6	5.1	2.3
Azadirachta indica	15.3	8.7	8.6	12.0	6.6	3.2
Tetracarpidium conophorum	12.7	4.3	4.9	6.2	5.2	2.4
Poultry droppings	13.0	7.7	5.4	10.8	5.4	2.6
Pleurotus tuberiegium	10.7	4.7	3.1	4.6	5.1	1.6
Control	7.3	1.7	2.9	2.5	2.8	0.8
MEAN	**11.9**	**5.6**	**5.1**	**6.8**	**5.1**	**2.2**
$LSD_{(0.05)}$ for year	2.057		17.79		0.946	
$LSD_{(0.05)}$ for Treatment	13.20		NS		NS	
$LSD_{(0.05)}$ for interaction	3.848		NS		NS	

Table 3: Effect of natural products on final nematode population and number of galls per plant on okra infected with root-knot nematode in 2021 and 2022 cropping seasons

	Initial nematode population		Final nematode population		Number of galls per plant	
Natural Products	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Cassava peel	800.0	900.0	97.0	169.0	1.6	4.3
Alchornea cordifolia	933.0	967.0	133.0	290.0	2.0	6.7
Azadirachta indica	867.0	900.0	63.0	133.0	1.0	3.0
Tetracarpidium conophorum	733.0	847.0	107.0	300.0	1.9	6.0
Poultry droppings	967.0	900.0	82.0	165.0	1.3	4.0
Pleurotus tuberiegium	733.0	800.0	200.0	377.0	3.0	7.3
Control	900.0	887.0	418.0	1000.0	8.5	16.7
MEAN	**848.0**	**886.0**	**157.0**	**357.0**	**2.6**	**6.8**
$LSD_{(0.05)}$ for year	NS		140.2		3.012	
$LSD_{(0.05)}$ for treatment	350.4		500.5		5.64	
$LSD_{(0.05)}$ for interaction	NS		26.3		NS	