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Effects of Bone Meal and Coconut Shell-Based Organic Amendments on Growth, Yield, and Root-Knot Nematode (*Meloidogyne incognita*) Suppression in Jute Mallow (*Corchorus Olitorius L.)*

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ABSTRACT
Jute mallows are infected by root knot nematodes which results in quantitative losses at harvest. This study's objective was to investigate the efficacy of powdered extract of bonemeal and coconut shell in controlling root knot nematode infecting jute mallow. The experiment was carried out to determine the efficacy of powdered extracts on the control of root knot nematodes in Jute mallow plants. The statistical design was a completely randomized design. Data were collected on plant height, number of leaves, shoot weight, root weight, yield and soil nematode populations and root galling index. Numerical data were subjected to analysis of variance (ANOVA) and mean differences were determined by Duncan's Multiple Range Test (DMRT) at 5% level of significance using SAS 9.3. Treating *Corchorus olitorius* with powdered bonemeal extract resulted in a significantly better ($p>0.05$) height and yield (16.83 cm and 10.93g) than the other treatments. Significant variations were found between the shoot, root and yield weights of treated plants and their control counterparts. The negative control had the highest number of soil and root nematodes. Significant increase of galled roots (5.00) was also observed in the negative control. The treated plants performed much better than the control plants. The experiment also revealed some constituents, such as crude protein, ash and fiber. Based on this study's findings, it is advisable to make use of these amendments on root knot-infested farms, as they are cost effective, cheap and available alternatives to chemical nematicides, which are expensive and not environmentally friendly.

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INTRODUCTION

Jute mallows (*Corchorus olitorius* L.) is a fibrous flowering plant in the genus *Corchorus* belonging to the family Malvaceae (Abdel-Razek et al., 2022; Pholoma et al., 2024). It is endowed with higher fiber contents and highly perishable vegetables, also one of the main fiber crops in the world and specifically in Nigeria (Benor et al., 2012). It has many local names in Nigeria, 'Ahihiara'in Igbo, 'malafiya in Hausa and Ewedu' in Yoruba.
The leaves are a rich source of, calcium, thiamin, protein, riboflavin, niacin, iron, foliate, and dietary fiber (Ndlovu and Afolayan, 2008). In Nigeria, concoction prepared from the seeds of *C. Olitorus* are used as purgative (Fondio and Grubben, 2004) also root scrapings of the same plant are used to treat toothache in Kenya.
The production and yield of *C.olitorius* is challenged by poor cropping system, abiotic and biotic factors particularly plant parasitic nematodes. *Meloidogyne* species pose a significant threat to crop production in Africa due to the losses they cause on a wide range of agricultural crops. It causes an estimated annual loss of $157 billion globally (Abad et al., 2008). Root knot nematodes can cause high levels of crop loss during development (Apalowo et al., 2025), increase the cost of production through increased fertilizer application and control strategies, and also significantly reduce yields. The leaves of crops become yellowish (green to yellow), wilt and finally drop.
The roots become galled and the presence of these galls is the most characteristic symptom of infection. In severe infections, there may be complete loss of plant vigor resulting into heavy yield losses. Therefore, there is always the need to curtail their excesses on the growth and yield of the crop.
Use of chemical nematicides is very common in the control of RKNs despite their threat to environmental and human health. Recently, restrictions on using some chemicals have been enforced. So, there is a need of potential environmentally benign strategies to the control of RKNs (Khan et al., 2023). Information on the impact of root-knot nematodes (*Meloidogyne incognita*) on Jute mallow is scant. Hence, the aims and objectives of the study are to determine the potential nematicidal effects of powdered coconut shell and cattle bone meal on *M. incognita* population, yield of *C. olitorius* and compare the efficacy of the two treatments.

MATERIALS AND METHODS

Experimental site

This experiment was carried out in the screenhouse of the Department of Crop Protection, University of Ilorin, Nigeria.

Soil Pasteurization

Sandy- loam topsoil was collected from the farmland around Department of Agronomy Pavilion, University of Ilorin, Ilorin. Using method described by Gautama and (Goswani, 2002), the soil was steam pasteurized in a drum at 90°C for 9 hours. The steam pasteurized soil was allowed to sufficiently cool for 72 hours. Thereafter, 8.5 kg of the pasteurized soil was weighed into each of 32 perforated 10 L plastic buckets of 11 cm in diameter. The buckets were placed on elevated platform to avoid reinfestation by other microorganisms and they were kept inside screenhouse where they were used for planting.

Collection and preparation of soil amendments

Preparation of Powdered Cattle Bone

Cattle bone was collected from Saraki Abattoir Ilorin, Kwara State; Nigeria. It was washed and boiled separately in distilled water for about 2 hours at 100˚C. The meat adhered was cleaned manually from bone frame and washed with water. Then the bone was broken into small pieces, and it was immersed into distilled water and autoclaved for about 45 minutes at 121˚C. They were dried in the hot air oven at 60˚C for about 6 hours. Dried bone was grinded well. Motor and pestle were used to make fine bone powder. The cattle bone powder was stored in plastic container at room temperature for further nutritional composition analysis and application.

Preparation of Powdered Coconut Shell

The outer pericap of coconut shell (Cocos nucifera) were collected from Ipata Market Ilorin, Kwara State, Nigeria. The shell were washed with distilled water and air dried, later grinded into fine powder using Motor and pestle .The grounded powder were sieved with 2mm mesh pore size and were kept in plastic container at room temperature for further nutritional composition analysis and application.

Nutritional Composition of Bonemeal and Coconut Shell

The nutritional composition of powdered bone and coconut shell were analyzed for moisture, ash and other extracts like crude fat, crude fibre and protein were determined using standard methods (AOAOC, 1990). Nitrogen was determined using the micro-kjedahl method (Pearson, 1976) and the crude protein was taken as N% x 6.25 (constant factor) where N is equal to Nitrogen content per 100g sample. Na and K were determined by the Jenway P9P7, Flame photometer method. The crude fibre was obtained by dry ashing of the sample at 550oC dissolved in 10% HCl(25ml) and 5% Lanthanum Chloride (2ml) boiled, filtered and made up to standard volume with distilled water. Phosphorus was determined using the spectronic 20 calorimeter by the phosphovando molyb date method (AOAC, 1990) and (Dubois et al., 1956). Ca and Mg were obtained by EDTA method (Ademoroti, 1996). However, the heavy metals were determined using atomic absorption spectrophotometer.

Collection and Extraction of Inoculum

Galled roots of *Celosia argentea* were collected from established pure culture in the Screenhouse. Eggs from infected roots were extracted using Sodium hypochlorite method as described by Boyhan et al. (2003) a solution of Sodium hypochlorite and distilled water was prepared in the ratio 1:9 and mixed thoroughly. The solution was added to chopped infected roots in a beaker and agitated for four minutes. The resulting solution after four minutes was passed through 250 µm, 70 µm, 45 µm and 25 µm mesh sieves. Larger roots and other debris were collected by 250 µm, 70 µm and 45 µm sieve while nematode eggs were collected by 25 um sieve after thoroughly washing with distilled water. The nematode egg suspension was standardized using a stirrer such that 1ml contained approximately 100 eggs. An aliquot of 1 ml containing 100 eggs.

Soil Physical and Chemical Analysis

Five core soil samples were randomly taken from each of the blocks at 0-10cm depth before planting and mixed in polythene bag to form a composite core sample and were properly labeled. The samples were taken to Soil science laboratory of Department of Agronomy, Faculty of Agriculture, University of Ilorin, Ilorin to identify constituents present in the soil and to ascertain the soil physical and chemical properties using the Kjedahl method. Same procedure was also repeated at harvest.

Sowing, Inoculation and Amendments application

Ten liters perforated plastic buckets of 11cm in diameter were filled with cool pasteurized soil of 8.5kg and the buckets were placed on an elevated platform to avoid reinfestation by other microorganisms. The experimental set up was arranged in a 1×5 factorial experiment fitted into a Completely Randomized Design (CRD) with eight replications. A total of 40 buckets were used. Two seeds were planted into each bucket and allowed to germinate. At a week after planning, three holes were carefully marked at the base of each plant using glass rod for inoculum incorporation. Thirty- two (32) buckets were inoculated with 100 eggs of *Meloidogyne incognita* and inoculated plants received treatments which are powdered cattle bone and coconut shell at the third day of inoculation and this was repeated a month after the first application at rate of 50g each. Uninoculated plants (8 buckets) that were not inoculated served as positive control and inoculated plants (8 buckets) that did not receive treatments also served as negative control. Maintenance practices such as watering daily using watering can, weeding by hand picking and insect control were carried out using 5% cypermetherin insecticide.

Nematodes Extraction and Estimation

The soils and roots were sampled for nematode population after one month of sowing and at harvest. The extraction was carried out in the Biotechnology laboratory of Faculty of Agriculture, University of Ilorin, Ilorin, Nigeria using Barman tray method as described by White head and Hemming (1965).

Soil samples were collected from the buckets into properly labelled polythene bags and were taken to the laboratory. A soft ply tissue was laid in a sieve and the sieve was placed in a tray. Two hundred grams of the soil was poured into the sieve and water was gently poured in each of the tray for easy migration of nematode into water. The extraction was left for 72 hours. The supernatant was collected in beakers, decanted and was observed and estimated under Stereomicroscope.

Data Collection

Data collected were on length of plant, number of leaves, stem girth, fresh shoot weight, fresh root weight, number of fruits, weight of fruits, soil and root nematode population and root gall index scored according to the method described by (Seid et al., 2019). The reproduction factor was calculated by dividing the final nematode population (Pf) by the initial nematode population (Pi); Rf = Pf/Pi. Each treatment was replicated eight times and details of treatments were below:

Treatment: Four

T-1: Buckets application with powdered cattle bone at the rate of 50 g

T-2: Buckets application with powdered coconut shell at the rate of 50g

T-3: Buckets application with both powdered cattle bone and coconut shell at 50g

T-4: Uninoculated buckets as positive control

T-5: Inoculated buckets as negative control

Root systems were uprooted, washed and the root galls were scored using (Seid et al., 2019) method as described below;

0 = No galls (clean root system)

1 = 1-10% of the root system galled
2 = 11-35% of the root system galled
3 = 36-65% of the root galled
4 = 66-90% of the root system galled
5 = 91-100% of the root system gall

Data Analysis

Analysis of variance (ANOVA). The mean differences were determined by Duncan's Multiple Range Test (DMRT) at 5% level of significance using SAS 9.3.

RESULTS AND DISCUSSION

Table 1 displays the proximate analysis of the two organic amendments.

There is no difference between the moisture content of the two ground powders with (8.50 and 8.56). Ground bone meal recorded higher value of crude protein (4.70) than ground coconut shell with (3.28). Ash content of coconut shell is lower in value (2.33) than bone meal (3.28). Fat content of powdered bone meal is higher in number than that of coconut shell (11.66 and 10.54) respectively.

Table 1. Proximate Composition of Ground Powdered Cattle Bone and Shell of Coconut (Mg/100g)

Parameters	Coconut (%)	Bone meal (%)
Moisture content	8.50	8:56
Crude protein	3.28	4:70
Ash	2:33	3:28
Fat	10:54	11:66
Fiber	37:58	36:58

Table 2 shows comparative results of physical and chemical composition of soil before planting and at harvest. Most of the pr-planting soil chemical constituents increased in amended soil at harvest, soil pH at 4.00 before planting improved to 5.82 pH at harvest for plants treated with powdered coconut shell and plants treated with powdered bonemeal recorded 6.70. Other chemical constituents such as Nitrogen, Organic Carbon, Organic Matter, Calcium, Magnesium, Sodium and Potassium were increased at harvest for plants treated with powdered bone meal. Soil acidity was decreased to low acidity in both treated plants.

Table 2: Chemical Constituents of Soil at Pre- Planting and At Harvest

SC	SCVBS	CSS@H	BMS@H
pH (H_2O) 1:1	4.00	5.82	6.70
pH (KCl) 1:1	4.35	4.84	5.68
Nitrogen	0.20	0.29	0.89
Organic Carbon	0.38	0.48	3.29
Organic Matter	0.82	0.88	2.67
Calcium	2.05	4.20	10.89
Magnesium	1.10	1.30	3.60
Sodium	0.14	0.17	1.74
Potassium	0.65	0.79	5.67
Acidity	1.20	5.20	6.40
CEC	3.90	3.67	5.87

Note: sc = soil constituents; scbs = soil constituents before sowing; cssc@h = coconut shell treated soil constituents at harvest and bmsc@h = bonemeal treated soil constituents at harvest

Table 3 shows the effect of organic amendment on the plant height (cm) of Jute mallow infected with Root-Knot Nematode. There were no significant differences in between the treatments in week 2. Significant differences displayed in the fourth (4) week between the treatments. Treated plants observed higher height than untreated ones (control - and +). At week 10, plants treated with powdered bone meal recorded highest value in heights, this was followed by plant treated with powdered coconut shell having 16.83 cm and 12.87 cm respectively. Combined treated plants recorded 12.17 cm as plant height. Negative (-) control plants observed lowest value on plant heights, followed by control positive (+) plants.

Table 3: Effect of Organic Amendment on the Plant Height (Cm) of Jute Mallow Infected with Root-Knot Nematode

Treatments	Week 2	Week 4	Week 6	Week 8	Week 10
Coconut	5.03 ± 0.29^a	8.40 ± 0.20^a	9.77 ± 0.18^b	9.23 ± 0.37^{bc}	12.87 ± 1.59^b
Bonemeal	5.73 ± 0.53^a	8.77 ± 0.19^a	10.03 ± 0.67^a	13.53 ± 1.87^a	16.83 ± 1.86^a
Combination	5.30 ± 0.21^a	8.33 ± 0.71^a	9.40 ± 0.46^b	12.90 ± 0.95^b	12.17 ± 1.30^c
Control Positive	6.07 ± 0.47^a	7.10 ± 0.23^b	8.20 ± 0.42^{bc}	8.43 ± 1.34^c	10.13 ± 2.37^d
Control Negative	5.97 ± 0.29^a	6.77 ± 0.39^b	7.97 ± 0.61^c	8.67 ± 0.90^c	8.93 ± 0.62^e

Note: values with different letter are significantly different at 5% level of significance (using tukey test.

Table 4 shows effect of treatments on the number of leaves of Jute mallow infected with root-knot nematode on number. There were significant differences in between the treatments in week 2. Significant differences displayed in the fourth (4) week between the treatments. At week 10, plants treated with powdered bone meal recorded highest number of leaves, this was followed by plant treated with powdered coconut shell having 28.67 and 18.69 respectively. Combined treated plants recorded 14.33 as number of leaves. However, treated plants observed higher number of leaves than untreated ones (control - and +). Positive (+) control plants observed lower value of leaves (10.63) compared with negative control. Least number of leaves was recorded by control negative (-) plants having 7.62 numbers of leaves at week 10.

Table 4: Effect of Treatments on the Number of Leaves of Jute Mallow Plant Infected with Root-Knot Nematode

Treatments	Week 2	Week 4	Week 6	Week 8	Week 10
Coconut	$5.00{\pm}0.00^{a}$	6.00 ± 0.56^{a}	8.00 ± 0.58^{a}	$14.33{\pm}0.33^{b}$	$18.69{\pm}0.33^{b}$
Bone meal	$3.67{\pm}1.15^{b}$	5.00 ± 0.00^{b}	$8.67{\pm}0.33^{a}$	$16.33{\pm}.033^{a}$	$28.67{\pm}0.33^{a}$
Combination	5.33 ± 0.58^{a}	6.00 ± 0.58^{a}	$8.33{\pm}0.33^{a}$	$10.33{\pm}0.67^{c}$	$14.33{\pm}0.33^{c}$
Control Positive	4.00 ± 0.00^{b}	5.33 ± 0.33^{b}	$6.33{\pm}0.33^{b}$	$8.67{\pm}0.33^{d}$	$10.63{\pm}0.67^{d}$
Control Negative	$3.33{\pm}0.33^{c}$	3.67 ± 0.33^{c}	$4.00{\pm}0.00^{c}$	$4.33{\pm}0.33^{e}$	$7.62{\pm}0.33^{e}$

Note: values with different letter are significantly different at 5% level of significance (using tukey test.

Table 5 displays effect of treatments on the shoots and roots weight (g) of Jute mallow. There were significant differences between the treatments in the table. Shoots weight of powdered bonemeal indicated highest value with (12.07), this was followed by plants treated with powdered coconut shell. Combined treatment recorded 10.78 g weight of shoot. Control (-) plants had the least weight of shoots and was followed by control (+) plants both having 4.34 and 6.77 respectively.

Roots weight of control (-) plants observed the highest weight having 12.53 g, this result was followed by combined treated plants with 10.81. Control (+) plants recorded the least weight of roots (6.03). The root weight of plants treated with powdered coconut shell had higher value (9.14) in weight than plants treated with powdered bonemeal having 7.15 of weight.

Table 5: Effect of Organic Amendments on the Shoot and Root Weight (G) of Jute Mallow Plant Infected with Root-Knot Nematode

Treatments	Shoot Weight	Root Weight
Coconut	$8.33 {\pm} 0.36^{c}$	9.14 ± 0.19^{c}
Bonemeal	12.07 ± 0.07^{a}	7.15 ± 0.19^{d}
Combination	10.78 ± 0.19^{b}	10.81 ± 0.14^{b}
Control Positive	6.77 ± 0.23^{d}	6.03 ± 0.08^{e}
Control Negative	4.34 ± 0.17^{e}	12.53 ± 0.32^{a}

Note: values with different letter are significantly different at 5% level of significance (using tukey test

Table 6 shows effect of organic amendments on yield weight (g) of Jute mallow plant infected with root-knot nematode. There were significant differences between the treatments in the table. Yield weight of powdered bonemeal recorded highest value with (10.93), this was followed by plants treated with powdered. Combined treatments which recorded 7.80 g weight of yield. Control (-) plants had the least weight of yield and was followed by control (+) plants both having 2.73 and 5.97 respectively. Plant treated with powdered coconut shell had 6.47 g.

Table 6: Effect of Organic Amendment on Yield (G) of Jute Mallow Plant Infected with Root-Knot Nematode

Treatments	Yield
Coconut	6.47 ± 0.57^{c}
Bonemeal	10.93 ± 0.60^{a}
Combination	7.80 ± 0.47^{b}
Control Positive	5.97 ± 0.55^{d}
Control Negative	2.73 ± 0.28^{e}

Note: values with different letter are significantly different at 5% level of Significance using tukey test.

Table 7 shows effect of organic amendment on the soil and root nematode population of root-knot nematodes infected Jute mallow with root-knot nematode. Significant differences were displayed here. Negative control plant root and soil recorded highest number of root nematodes (10.67, 28.00) and (51.69, 88.33) at one month and harvest respectively. This was followed by plant root and soil treated with powdered shell of coconut having (4.67, 9.66) and (36.35, 48.00). Jute mallow roots and soils that were treated with combination of the treatments observed the least population of nematodes (0.33, 1.00) and (21.00, 9.43) and was followed by plants treated with powdered bonemeal observing (1.00, 1.06) and (22.37, 10.67). However, positive control plants recorded 0.00.

Highest reproduction factor was observed in control negative soils with 0.88 and the least was noted in soil treated with combination of powdered bonemeal and coconut shell.

Table 7: Effect of Organic Amendment on the Soil and Root Nematode Population of Infected Jute Mallow with Root-Knot Nematode

Treatments	RNPW	RNPH	SNPW	SNPH	RF
Coconut	4.67 ± 0.33^{b}	9.66 ± 0.33^{b}	36.35 ± 0.33^{c}	48.00 ± 0.00^{c}	0 .48 ± 0.09^{c}
Bonemeal	1.00 ± 0.58^{b}	1.06 ± 0.58^{a}	22.37 ± 0.33^{b}	10.67 ± 0.33^{b}	0.10 ± 0.03^{b}
Combination	0.33 ± 0.67^{a}	1.00 ± 0.00^{a}	21.33 ± 0.33^{a}	9.43 ± 0.33^{a}	0.09 ± 0.06^{a}
Control positive	0.00	0.00	0.00	0.00	0.00
Control negative	10.67 ± 0.88^{c}	28.00 ± 2.08^{c}	51.69±1.69^{d}	88.33 ± 1.67^{d}	0.88 ± 0.40^{d}

Note: values with different letter are significantly different at 5% level of significance (using tukey SNPH test. keys: RNPW = root-knot nematode population at week 7; RNPH = root-knot nematode population at harvest; SNPW = soil nematode population at week 7; = soil nematode population at harvest and RF = reproduction factor. Effect of organic amendment on root galling of Jute mallow infected with root-knot (Table 8) shows significant differences between the treatments. Control plant roots recorded the highest galling rates with 5.00, this was followed by Jute mallow roots treated with powdered coconut shell having gall index as 1.33. Plants roots of combined treatments displayed the lowest galling index as 0.00 and was followed by roots treated with powdered bonemeal having 0.45 galling index. Control positive was not inoculated and treated.

Table 8: Effect of Organic Amendment on Root Galling of Jute Mallow Infected With Root-Knot

Treatments	Gall Index
Coconut	1.33 ± 0.67^{b}
Bonemeal	0.45 ± 0.58^{c}
Combination	0.00 ± 0.55^{c}
Control Positive	0.00 ± 0.00
Control Negative	5.00 ± 1.15^{a}

Discussion

The experiment showed that root knot nematodes significantly decreased the height, number of leaves and yield of jute mallow plants grown in nematode-infested soil, which resulted to retarded growth compared to their treated counterparts. The treatment powdered extracts of coconut shell and bonemeal significantly improved jute mallow growth, yield and reduced the soil and root nematodes.

The effect of the organic amendments might be due to the presence of organic compounds such as crude protein, ash and fiber. These findings are consistent with previous studies of (Basuki, 2019; Hodson, 2006 and Atemni et al., 2003) which reported that amendment of bonemeal to the soil can lead to a 1000 folds increase in beneficial soil microorganisms, creating a hostile environment for pathogens; bonemeal releases organic compounds that may have antimicrobial properties or alter microbial dynamics and use of coconut shell charcoal gave a significant effect on the number of root noodle of *A. magium* seedlings respectively.

Among the organic amendment extracts, the powdered of bonemeal extract had the greatest influence on jute mallow growth and yield, followed by coconut shell *extract*. Both powdered bonemeal and coconut shell extracts performed better than the controls in terms of growth and yield. Inoculated control jute mallow (- ve) had a high level of susceptibility to root knot nematode, as evidenced by its heavily galled roots. This was followed by jute mallow treated with powdered coconut shell, which showed a moderate level of susceptibility with few root galls. Non-inoculated (+ ve) controls had clean roots.

Generally, all jute mallows treated with organic amendments performed significantly better than their control counterparts, showing increased growth and yield and reduced galling rates. The plant extracts were successful because they contained organic compounds such as crude protein, fiber and ash, which may have been responsible for stopping nematodes from feeding, migrating, enabling cell development and reproduction, and inflicting plant harm.

Crude protein support soil microorganisms, such as bacteria and fungi, which play a crucial role in decomposing organic matter and fighting nematodes. Crude protein provides energy for these beneficial microbes, supporting their growth and activity. A balanced soil microbiome helps suppress nematode populations (Yadav et al., 2021).

Fiber in the soil particularly as organic matter is crucial for soil health and nematode control. Fiber provides food for beneficial microorganisms, supports soil structure, and helps regulate soil moisture. Decomposing fiber releases compounds that can repel or kill nematodes, reducing their populations (Usharani et al., 2019)

Ash as inorganic matter, affects soil structure and pH. Well-balanced ash content ensures optimal soil porosity, aeration, and water-holding capacity, creating an environment unfavorable for nematode survival. Certain ash components, like silicon, can also enhance plant defense against nematodes (Usman, 2000).

The significant performance of powdered bonemeal on growth and yield and its effect on soil and root nematodes might be due to the high presence of crude protein and ash, which was present in the extracts. According to (Sneddon et al., 2006), who reported that bone meal releases organic compounds that may have antimicrobial properties or alter-microbialdynamics. The inoculated and treated plants responded well to the pathogen as well as the amendments, however, plants that were not inoculated and treated also recorded high growth and yield, this could be attributed to some inherent genetic characteristics of the plants. Combined treated plants recorded lower plant growth and yield compared to single treatments; this might be due to excess crude protein that retards the growth. However, combined treated soil observed lowest soil nematodes and zero roots galling.

Soil physical and chemicals analyses revealed high differences between soil before planting and soil after planting of the two amendments. Chemical properties at harvest in the amended soil revealed lower soil acidity and increased constituents such as calcium, nitrogen and organic

carbon when compared with initial soil. However, soil amended with bonemeal recorded lowest soil acidity and increased value of calcium, nitrogen and organic carbon.
Sufficient soil amendment with powdered bonemeal and coconut shell work together to create an environment that supports beneficial microorganisms, which fight nematodes, enhances soil structure and moisture management by making it less conducive to nematode survival and provides energy and nutrients for plant growth, making them more resistant to nematode attacks.
Farmers are therefore encouraged to create a soil environment that naturally suppresses root knot nematode populations, reducing the need for chemical nematicides.

CONCLUSION

This work suggests that powdered bonemeal and coconut shell extracts can be utilized in the control of root knot nematodes and may have potential as bio-pesticides for the control of nematodes, as they displayed nematicidal properties.
The experiment also revealed the presence of crude protein, fiber and ash content of the two-material used as soil amendments
The jute mallow treated with bonemeal powdered performed better than coconut shell treated jute mallow plants because it displayed clean roots (no galls) at harvest. Powdered bonemeal can be considered for integrated disease management. It is a sustainable and eco-friendly option.
It is encouraged to use the two soil amendment because their effect can persist for years after a single application. More research might help to determine an appropriate concentration of the botanical extract to be applied to soils highly infested with *M. incognita.*

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