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Original article

Impact of improved soil physico-chemical parameters on nematode population dynamics.

***Ekine, E.G. and Ezenwaka, C. O.**

Department of Biology, Federal University Otuoke, Bayelsa State, Nigeria

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ABSTRACT

Plant growth relies on soil nutrients. An agricultural soil's ability to remain viable is largely dependent on its physicochemical characteristics, which can be restored through artificial or natural fertilizer. When added to the soil as amendments, waste for soil enhancement can positively impact soil physicochemical parameters and active associations, reducing pathogen populations in cultivated fields. A study to determine the impact of improved soil physico-chemical parameters on nematode population dynamics was conducted using raw poultry filters. Soil sampling was done prior and post improvement of soil physicochemical features by parasitological technique. Soil was collected using a modified soil auger on 0-15 cm depth. The extraction of nematode was done using the modified sieve plate technique and nematodes were identified using nematode pictorial key. Sampling before the improvement of the physicochemical parameters of soil revealed a total of 216 nematodes from 8 genera while post application of composited poultry droppings had a total of 601 nematodes from 16 genera. High dynamics on nematode population was reported from the experimented plot after the improvement of soil physiochemical parameters on application of composited poultry droppings. This observation is indicative that improvement of soil physicochemical features impact positively on nematode propagation. The study also noticed that the populations of phyto-parasitic nematodes decrease as omnivorous and predatory nematodes reports a reasonable increase in the soil post soil improvement, which depicts that the use of omnivorous nematodes, if properly sourced, may fit in as an alternative option in the management and control of plant feeding species of nematodes in the soil.

Keywords: Improved, Population dynamics, Physico-chemical features, Poultry droppings, soil, nematodes.

Corresponding author' s email: emmanuelgreen95@gmail.com, Phone Number: +234(0)8076621065

INTRODUCTION

Soil is a significant factor on which plants rely on for survival. It is a self existing medium for the supply of food and nutrient for adequate plants growth. The soil displays a variety of features which is beneficial to living things ranging from plants and animals including human. Because of its heterogeneous nature, soil exhibits a significant regulatory role in the ecosystem that unfastens regenerative viable agronomic activities [1-3]. It can be influenced by agricultural management strategies through positive and negative measures including the incorporation of natural and synthetic fertilizers [4,1]. According to some authors [5,1,3,6], soil could serve as a filter and a system for the transformation of relevant beneficial elements and keep the global ecosystem safe from harmful contaminants. Soil is a natural asset on which human rely on its produce for the continuity of life.

The viability of an agricultural soil is virtually dependent on its physicochemical properties. The physicochemical features of each soil type constitute a major determinance in its life sustaining function and can be renewed on the incorporation of fertilizer, either natural or man-made. The addition of fertilizers in the soil has been reported to activate its constituted features and aid improvement of crops [7,1]. A variety of studies [8-10,6] reported that the culture of using fertilizers in agriculture to boost soil nutrient have impacted positively on its physico-chemical features and have also resulted in gradual reduction of infections initiated by soil pathogenic microbes in cultivated field across the globe. The waste for soil enhancement when inserted as soil amendments could boost the ability of the soil to conserve sufficient water, prompt modifications in the soil ecosystem, ameliorate the natural removal in clay environment and impact active associations [7,11]. Therefore, testing the impacts of soil improvement using poultry droppings on nematode dynamics is significant.

Plant parasitic nematodes pose a threat to farmers in Nigeria, causing food shortages. To achieve food security, effective control strategies are needed. Understanding the role of poultry droppings on nematode dynamics and soil improvement could help initiate control strategies to avert the negative signals on food security imposed by phyto-parasitic nematodes. This study evaluates the impact of improved soil physico-chemical features on nematode population dynamics using poultry filters.

MATERIALS AND METHODS

Acquisition of research site: The experimental field used for this study was acquired from Marvin family in Iwofe community, Port Harcourt; 2 km away from Ignatius Ajuru University of Education, Port Harcourt. The experimental site measures 30 m x 30 m and is located in $4^{0}51^{1}27^{11}$N $6^{0}38^{1}50^{11}$E.

Field Layout: The indigenous vegetations occupying the experimental site (30 x 30 meters) were removed manually with the used of domestic cutlass prior to soil sampling and the application of poultry droppings as organic fertilizer for the improvement of the physicochemical properties of soil.

Experimental design: This study adopted a randomized complete block design to ensure equal selection opportunities for all groups.

Preparation/application of poultry droppings: The poultry droppings used in this study was prepared in improvised set-up using poultry dung from Opelia farm, Port Harcourt. Raw poultry filters were emptied into a hole of 3 fit depths and the set up was turned on twenty-four hours interval with the use of a strong 2 by 2 m stirrer to homogenize the poultry dung. This set up was allowed to stay for fourteen days to ensure proper decomposing and provision of manure. The mature was harvested and applied as organic manure.

The composited poultry manure was randomly applied on the experimented plot. The application was done on the surface of mulch using a hand trowel at the rate of 2kg across the experimented plot and was left to mineralize for 18 days before commencement of second phase of soil sampling to determine nematode population dynamics.

Determination of soil physicochemical properties: The soil physico-chemical parameters were improved with the use of composited poultry filters as organic manure. The physico-chemical properties of the soil were assessed before the application of poultry droppings using a method outlined [12,13]. The indigenous nematodes of the experimented plot were also determined before and after soil improvement.

Bed preparation: 25 beds of 15-meter length were made after clearing the experimented plot.

Sampling Procedure:
Immediately after clearing of the experimented plot, fifty (50) soil samples were randomly collected within a depth of 0-15cm to test the indigenous nematodes of the plot. Soil collection was repeated seven days after bed preparation, before applying composited poultry droppings, following the first sampling. The samples were analyzed for nematode population prior to improving the soil's physico-chemical properties.

Soil samples were again collected from the same plot fourteen and twenty-one days after the application of the composited poultry droppings at 0-15cm core depth. This was done to determine the nematode population dynamics after the application of composited poultry manure as an improvement strategy for soil physicochemical properties. The soil samples were bagged in well labeled waterproof bags and transported to the research laboratory for nematodes extraction.

Nematodes extraction from soil
The modified sieve plate method as described [14] was employed for nematode extraction. The soil samples in each white waterproof bag were emptied into a 5 m by 7 m plate and examined to detect and discard debris, after which a 100 sub samples of the soil were spread evenly on tissue paper supported on a plastic sieve standing in a plastic plate. Water was added gently until the soil is wet. The extraction set up was allowed to stand undisturbed for 48 hours in the laboratory. After which the soil was discarded and the nematode suspension poured into clean specimen bottles properly labeled and fixed with 2 drops of 5% formalin and allowed to settle for microscopic viewing and nematode counting and identification.

Nematode identification
Nematodes were detected using the x4 and x10 objectives of the light microscope and

identification was done using [15-17] pictorial keys.

Data analysis

Nematode percentage of occurrence at first sampling was achieved using n/N x 100, where n is the frequency occurrence of individual nematode genera; and N, the total nematode richness extracted in the study. Data obtained from the study were analyzed with paired t-test using Special Package for Social Science (SPSS) version 23. Nematode dynamics between the sampling stages was tested using ANOVA.

RESULTS

Nematodes population of the experimental plot prior to improvement of soil physico-chemical parameters.

First and second sampling of the experimented plot before the application of composited poultry droppings showed a total of 216 nematodes from 8 and 7 genera respectively. *Pratylenchus* species has the highest occurrence (19.0%), closely followed by *Heterodera* species (17.6%), while *Scutellonema* species (2.3%) occurred less than every other nematode from the samples soil before the application of composited poultry manure. Also, encountered in this phase of soil sampling were *Meloidogyne* species (17.1%), *Longidorus* species (15.3%), *Rhabditis* species (11.6%), *Radopholus* species (8.8%) and *Helicotylenchus* species (8.3%) (Table 1).

Table 1: Nematodes population before the improvement of soil physico-chemical features

Nematodes spp	First sampling No. (%)	Second sampling No. (%)	Overall occurrence No. (%)
Radopholus	12 (13.2)	7 (5.6)	19 (8.8)
Heterodera	21 (23.0)	17 (13.6)	38 (17.6)
Longidorus	8 (8.8)	25 (20.0)	33 (15.3)
Meloidogyne	16 (17.6)	21 (16.8)	37 (17.1)
Pratylenchus	18 (19.8)	23 (18.4)	41 (19.0)
Rhabditis	4 (4.4)	21 (16.8)	25 (11.6)
Scutellonema	5 (5.5)	0	5 (2.3)
Helicotylenchus	7 (7.7)	11 (8.8)	18 (8.3)
Total	**91 (42.1)**	**125 (58.9)**	**216**

P-value =0.223

Influence of poultry filters on soil physicochemical parameters.

In this study, 16 soil physico-chemical properties were tested. The result showed the average mean value of the physicochemical properties of the soil pre and post application of the composited poultry droppings (Table 2). Total Organic Content (TOC %) before and after the application of the composited poultry droppings were 0.78 % and 3.64% respectively. The Total Organic Matter (TOM %) was 1.35% and 6.04% respectively while Electrical conductivity (EC µm/cm) was 40.16µm/cm and 71.55 µm/cm at pre and post application. The Total Hydrocarbon (THC mg/kg) at pre and post application was 3.74 mg/kg and 5.82 mg/kg respectively while the pH value was 3.4 and 3.8 at pre and post application of composited poultry droppings. The result for Magnesium (Mg) showed 1.05 mg/kgand 5.21 mg/kg for pre and post application, Potassium (K) recorded 0.10% and 2.61% while the result for Nitrogen (N) was 0.03% and 4.05% at pre and post application respectively. Nitrate (NO_2^-) at pre and post inorganic fertilizer was 0.04mg/kg and 1.07mg/kg while Chlorine (Cl mg/kg) was 2.46 mg/kg and 6.56 mg/kg at pre and post application of inorganic fertilizer respectively. Calcium (Ca) available at pre and post application was 0.20 and 3.75while Phosphorus (P %) were 0.52% and 5.72% at pre and post application respectively. Ammonia (NH_4 mg/kg) in soil at pre and post application of composited poultry manure was 0.48 mg/kg and 2.09 mg/kg respectively whereas Sodium (Na) was 0.31 at pre application and 0.56 at post application while Manganese (Mn) were 1.45mg/kg and 5.12mg/kg at pre and post application respectively. The amounts of Zinc (Zn) at pre and post application of poultry manure were 0.42 mg and 3.44 mg respectively (Table 2).

Table 2: Influence of poultry manure on soil physico-chemical parameters.

Physico-chemical parameters	TOC %	TOM %	EC µs/cm	THC mg/kg	pH	Mg	K	N	NO_2^- mg/kg	Cl mg/kg	Ca	P %	NH_4 mg/kg	Na	Mn	Zn
BAOPM	0.78	1.35	40.16	3.74	3.4	1.05	0.10	0.03	0.04	2.46	0.20	0.52	0.47	0.31	1.45	0.24
AAOPM	3.64	6.04	71.55	5.82	3.8	5.21	2.61	4.05	1.07	6.56	3.75	5.72	2.09	0.56	5.12	3.44

BAOPM= before application of poultry droppings
AAOPM = after application of poultry droppings

Key:

TOC % Total organic content
TOM % Total organic Carbon
EC Electrical conductivity µs/cm
THC Total hydrocarbon mg/kg
pH Hydrogen concentration
Na Sodium ppm
K Potassium ppm
P % Phosphorus

NO_2^- Nitrate mg/kg
NH_4 Ammonia mg/kg
Zn Zinc mg/kg
Ca Calcium mg/kg
Mn Manganese mg/kg
N % Nitrogen
Cl^- Chloride mg/kg
Mg Magnesiummg/kg

Nematode population after the improvement of soil physicochemical parameters

Soil sampling after the application of composited poultry droppings to improve the soil physico-chemical properties revealed an overall assemblage of 601 nematodes from 16 genera. The reported nematodes were *Ditylenchus, Meloidogyne, Aphelenchus. Rhabditis, Longidorus, Paratylenchus, Dorylaimus, Hoplolaimus, Monochus, Monochid,Aphelenchoides, Tetylenchus, Arolaimus, Belonolaimus*, *Scutellonema* and *Hoplolaimus* species. The most prevalent species in this phase of soil sampling was *Rhabditis* species (9.7%), closely followed by *Paratylenchus* species (9.3%), while *Hoplolaimus* species appeared less than any other genera and species (Table 3).

Table 3: Nematode population after the improvement of soil physicochemical parameters

	Depth related occurrence		
Nematodes spp	**Third sampling No. (%)**	**Fourth sampling No. (%)**	**Overall assemblage No. (%)**
Aphelenchoides	24 (6.1)	20 (9.8)	44 (7.3)
Arolaimus	29 (7.3)	9 (4.4)	38 (6.3)
Belonolaimus	0	10 (4.9)	10 (1.7)
Ditylenchus	33 (8.3)	19 (9.3)	52 (8.7)
Dorylaimus	24 (6.1)	17 (8.3)	41 (6.8)
Longidorus	17 (4.3)	0	17 (2.8)
Paratylenchus	42 (10.6)	14 (6.8)	56 (9.3)
Rhabditis	35 (8.8)	23 (11.2)	58 (9.7)
Aphelenchus	48 (12.1)	8 (3.90	57 (9.5)
Hoplolaimus	19 (4.8)	0	19 (3.2)
Pratylenchus	33 (8.3)	7 (3.4)	40 (6.7)
Meloidogyne	22 (5.6)	0	22 (3.7)
Monochid	23 (5.8)	24 (11.7)	47 (7.8)
Tetylenchus	12 (3.00	7 (3.4)	19 (3.2)
Scutellonema	0	32 (15.6)	32 (5.3)
Monochus	35 (8.8)	15 (7.3)	50 (8.3)
No of genera : 16	**396 (65.9)**	**205 (34.1)**	**601 (62.0)**

Effects of poultry droppings on nematode community composition.

Nematodes actual incidence prior to soil improvement on application of poultry filters showed high populations of plant pathogenic nematodes in soil. Genera like *Pratylenchus* (19.0%) and *Meloidogyne* (17.1%) which have been reported as the most injurious nematodes on crop plants topped the list of nematodes. However, the population of nematodes was most composed of free-living species such as *Rhabditis* (9.7%), *Aphelenchus* (9.5%), *Monochus* (8.3%) in the research plot post soil improvement on application of poultry filters (Fig.1).

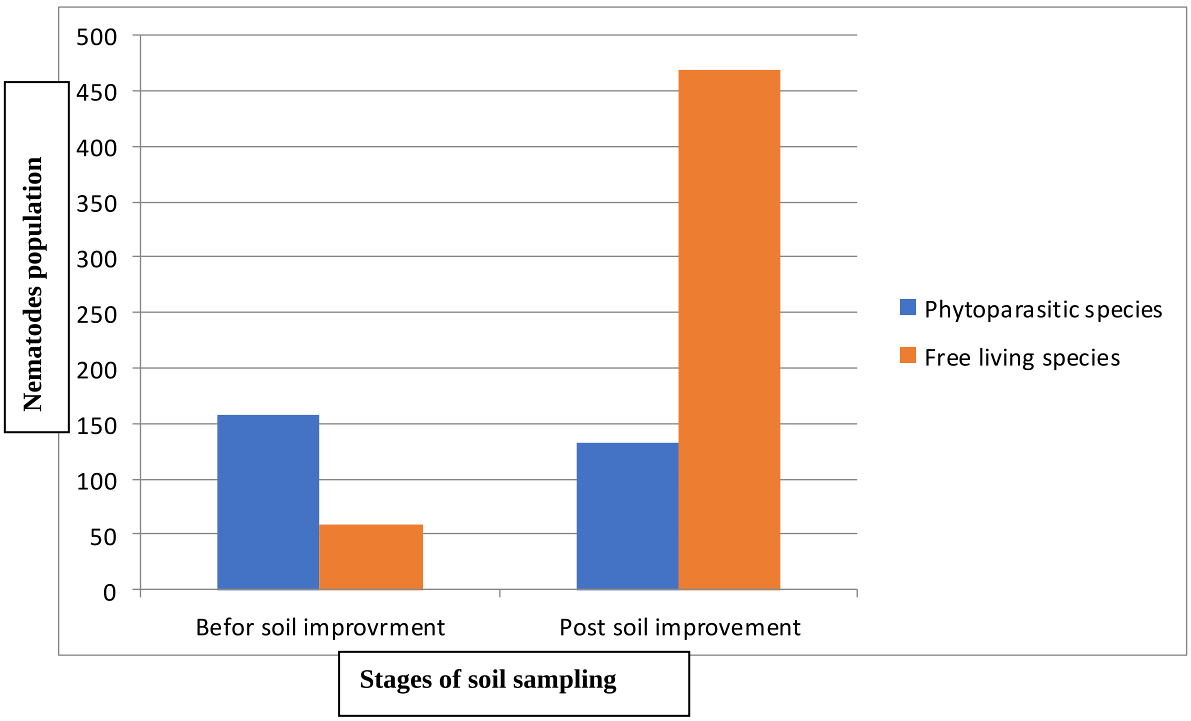

Figure 1: **Effects of poultry droppings on nematode community composition**

DISCUSSION

The use of organic fertilizer in improving soil physico-chemical features has expanded in recent times because of its significance in the amelioration of soil trace elements and stirring of the emergence of nematodes-feeding species in the soil, which may result to higher biodiversity of soil organism and ultimately increases nematodes associations in the soil and improve crop survival. In this study, the actual assemblage of nematodes before the improvement of the soil physico-chemical features was 216; a relatively low figure compared to the result of a similar study elsewhere [18] which recorded high nematodes assemblage at the fallowed undisturbed site. The low nematode population observed in the research plot before the improvement of soil physicochemical properties could be ascribed to the heterogeneous nature of the plot prior to clearing. This observation implied that diversity of the indigenous vegetations in the plot directly impacted on nematode population abundance in the field. Ekine *et al.* [14] opined that soil nematodes manifest host peculiarity in the field and may thrive well only in the presence of such host.

High dynamics on nematode populations was reported from the experimented plot after the improvement of soil physicochemical properties on application of composited poultry filters. The high dynamics on nematode genera and species noticed in the second phase of soil sampling depicts that the improved soil physicochemical features impacted positively on nematode propagation and possibly made the soil environment more conducive for nematode proliferation and profusion. It also suggests that composited poultry droppings enriched the soil with nutrient that was lacking earlier and made sufficient food available for nematode survival. Some authors [19,20,9] in their respective studies reported a lofty population of nematodes in soil on addition of inorganic and organic fertilizers. In this study nematode proliferation and survival rate was influenced by the improvement of soil physico-chemical properties on application of composited poultry filters.

The improvement of soil physico-chemical properties incited the emergence of latent species which comprises mainly of free-living genera and nematode-feeding genera. The population dynamics observed in this study may be ascribed to increase competition among nematodes owing to nutrient availability on application of the poultry droppings. It also indicates that the improvement of soil physico-chemical properties do not absolutely eradicate nematodes but add to its populations. However, it displayed higher populations of omnivorous/predatory species which depict danger for plant-feeding genera, hence can serve as a management option for plant-feeding nematodes. The widespread of nematodes noticed after the improvement of soil physico-chemical properties in this survey could also be attributed to favourable soil environment and the amelioration of trace elements. This observation is in conformity with [21,22] authors who suggested that improved soil trace elements by the application of animal fertilizers can stir heterogeneous interactions in soil organisms and improve nematodes associations in the soil.

The study found disparity in nematode community composition at soil sampling phases, linked to improved soil physico-chemical features with organic fertilizer addition, involving 216 nematodes from 8 and 7 genera. This observation may have been influence by limited soil nutrient and diversity in composition of vegetation cleared before soil sampling. However, the study found that nematodes population significantly increased after soil treatment with composited poultry droppings, reporting 601 nematodes from 16 genera. The variations on nematode abundance at each phase of soil sampling highlights the significance of improving soil physico-chemical properties on the profusion of nematodes using modern farming techniques which include using organic fertilizers like poultry droppings. Ekine [23] reported that the use of manure, either organic or inorganic, as a farming strategy has residual impact on soil physico-chemical features and could also influence soil organisms.

This survey found that phyto-parasitic nematode populations decreased as omnivorous and predatory nematodes increased reasonably in the soil post improvement, suggesting that omnivorous nematodes could be an alternative for managing plant-feeding nematode species in the soil if properly sourced. This concurs with the statement that an antagonistic interaction between phytophytic and omnivorous nematodes exists which may propel reduction of the phytophytic species [24,25].

CONCLUSION

Improvement on soil physico-chemical features impact on nematodes population dynamics and reduction on the populations of plant feeding nematodes is achievable in soil with the use of poultry droppings.

Declarations:

Ethical Approval: Not applicable

Conflict of interests: Authors declare that no conflicts of interest exist.

Authors' contributions: EEG designed the study protocol. Both ECO and EEG performed the field samples collection, laboratory analyses, analyzed and interpreted the data. EEG managed literature search and wrote the initial manuscript. All authors read and approved the final manuscript.

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