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Interaction Between Two Types of Earthworm and Ageratum on Soil Physicochemical Properties

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Abstract

Earthworms are one of the most important soil organisms in tropical ecosystem as they influence mineralogical, structural and microbial composition of soil. The study investigated the effect of interaction between two Nigerian earthworms *Eudrilus Eugeniae* and *Irridodrilus* sp and Ageratum species (AG) on soil physicochemical properties in potted experiment. The treatment consisted of 1000g subsoil treated with ageratum (AG); Ageratum + soil inoculated with *Eudrilus Eugeniae* (AE), Ageratum + soil inoculated with *Irridodrilus* sp (AI) and control soil not treated (CO). The results of the study showed remarkable differences between the treatments in soil physicochemical properties. The pots inoculated with *Eudrilus Eugeniae* (AE) relative to other treatments produced high quality ion exchange as evidence from the high (CEC) recorded, enhanced soil aggregation 73% compared to 52% recorded in AI, stabilization of soil aggregates and enhanced availability of nutrient elements by 150% compared to 120% observed in AI. High level of soil pH (9.15) was recorded in AE. AG induced 62% increase in soil erodibility and only 9% increase in availability of soil nutrients. AG was found to be toxic particularly to *Irridodrilus* whose percentage survival was 0% relative to 67% of *Eudrilus Eugeniae* whose weight loss was 27%. Ageratum is a bio-pesticide and bio-fertilizer of which its production is simple and cost effective and the efficacy for soil management will require the presence of active soil organisms like earthworms to process Ageratum adequately as was found in this study. The primary materials used in this study are abundantly available and within the reach of farmers. The production and application is eco-friendly, promotes sustainable soil productivity, soil conservation and environmental health. This technology will discourage the use of chemical pesticides and fertilizers in the study area if well integrated in crop production activities.

Keywords: Ageratum, chemical elements, earthworm, soil properties

1. Introduction

In Nigeria soil organisms particularly the earthworms abound. This organism can be harnessed and use to develop cost effective, high quality bio-fertilizer and bio-pesticides. Earthworms play a leading role in soil organic matter cum nutrient dynamic as they feed on decomposed organic materials at different stages of decomposition, through this activity as well as their burrows and cast production they help in dispersal of micro-organisms in soil. Earthworm have been noted to influence soil structure, nutrient cycling, crop yield, modification of soil porosity, stimulate and increase microbial activities and accelerate litter decay with greater C/N ratio than original resources by altering the physical, chemical and biological properties of the soil (Hale and Host 2005, Gonzalez 2002, Ammer et al., 2005, Sheehan et al., 2006, Jimens et al., 2006, Kooch and Jalivand 2008, Samaranayake and Wijekoon 2010, Nweke, 2017).

Ageratum is a plant that belongs to the tribe and family of Eupatorium and Asteraceae respectively. It is an erect annual, branched slender, hairy and aromatic plant approximately 1m in height. It is a native of West Africa, Asia, and Central America etc. Ageratum commodity grows in the proximity of habitation, thrives in any garden and agricultural soils. Among the weed members ageratum seem to be the most commonly spreading in most agricultural areas throughout the world. The specie is believed to posses various biological activities starting from its various phytochemical contents. Studies carried out using this plant has proved to be a positive weed controlling agent. The studies of Nagavellema et al. (2004) showed that the plant contains growth promoting hormones, anti-oxidant properties, and a good bio-fertilizer and offer the possibility of biocontrol of plant pathogenic fungi. Thus the plant possesses insecticidal and nematocidal bioactivities. The leaf, stem and flower are also used in analytical profile. One of the major areas Ageratum is used as biopesticides is in the seed treatment and soil amendment as compost were it helps to solve such problems as increased salinity and chemical run-off from the agricultural soils, it promotes soil fauna and flora improving soil formation, soil aggregation and stability, minimize erosion often caused by water runoff and wind.

Bio-fertilizers and bio-pesticides are properly acclaimed eco- friendly; renewable and health promoting commodity capable of promoting sustainable soil productivity and conservation. Among the benefits of these commodities are food security, mitigation of climatic crisis, job creation and environmental health. Hence ageratum can be sourced for the productivity of effective biopesticides in order to address problems particularly of nematodes, leaf eating beetle and maize grain weevil. This strategy will help to frustrate the ongoing use of hazardous pesticides by farmers. Development of high quality biofertilizer and biopesticides will promote and sustain food security, soil productivity, biodiversity and environmental health. The extract of which can be prepared by using natural materials such as plants and bacterial. Thus the essence of this study is to evaluate the effect of interaction between two types of earthworm and ageratum on soil physicochemical properties.

2. Materials and Methods

2.1 Site Description

The potted experiment was carried out in the Faculty of Agriculture Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus, Anambra State. The area is located within latitude 05^0 40 N and 06^0 45 N and longitude 06^0 40 to 07^0 20 E. The rainfall duration of the area is bimodal and temperature ranges from 25^0C – 35^0C with the relative humidity of 65%.

2.3 Earthworm Used for the Experiment

The two types of earthworm used are *Irridodrilus sp* and *Eudrilus eugeniae*. *Irridodrilus* are worms highly rich in organic mineral complex. The cast are typical spherical and ash brown in colour. Their activities in soil favours highly plant water availability and aeration porosity.

Eudrilus eugeniae belongs to epigenic specie and family of *Eudrilidae*, native of tropical Africa, but now widely spread in temperate region. They are very effective and efficient in plant litter degradation and decomposition, well noted natural machineries capable of transforming organic waste materials into vermicompost for agricultural application to boost soil fertility and crop yield (Nweke 2013)

2.4 Collection of Experimental Materials (Soil, Plant Residue, Earthworms and Pig Manure)

The Soil samples were collected by scrapping away 0 -5cm of the soil surface from Faculty of Agriculture Farm Land and 15 – 20cm deep was collected in a plastic container. After the collection, stones and hard clods were removed in order to ensure fine tilt before measuring out the soil. The soil was replicated into four different pots containing 1000g of soil. The earthworms used for the experiment were collected from open refuse dumpsite near one of the hostels in Chukwuemeka Odumegwu Ojukwu University Igbariam Campus, vegetation growing at the site were tridax procumbent, giant grass, sidarhombi folia etc. Ageratum specie was gotten from the Faculty of Agriculture Farm Land, while dried pig droppings was gotten from Animal Science Department of the institution. The result of the physicochemical analysis of soil used in the experiment are recorded in Table 1

2.5 Treatment Preparation, Allocation and Design

1000g of air dried soil samples were weighed into four (4) different plastic containers. Ageratum sp was chopped into pieces and 300g of it was thoroughly mixed with 300g of pig droppings and incubated in an air tight container for two (2) weeks. After the incubation, the treatment was aired and thoroughly mixed with the soil sample in the plastic containers. Three (3) containers were used to inoculate *Eudrilus eugeniae* and another three containers were used to inoculate *Irridodrilus sp* five earthworms respectively were inoculated per container and the experiment lasted for three months before harvest.

The treatment details are:-

Ageratum + Soil - (AG)

Ageratum + Soil + Eudrilus Eugeniae - (AE)

Ageratum + Soil + Irridodrilus SP - (A1)

Control Soil - (CO)

After three (3) months inoculation, the worms were harvested by hand sorting and were weighed collectively per container.

2.6 Laboratory Analysis

At the end of the study, soil samples were collected at two different spots in the container, bulked and used for physicochemical analysis. Also all analysis was carried out in three (3) replicates and averages with standard deviation adequately computed, recorded and tabulated in tables.

2.7 Soil Acidity ($H^+ Al^{3+}$)

Soil exchange acidity was analyzed electrically by a modified IN KCl displacement method of Mc lean (1965).

2.8 Total Dissolved (Soluble) Cation

The parameter was analyzed electronically using a digital conductivity meter on the soil: water ratio of 1: 2.5, while digital electrical meter was used to measure the net electrical charge.

2.9 Cation Exchange Capacity (CEC)

The cation exchange capacity (CEC) was determined by the method of Nikol (1959)

2.10 Base Saturation

Base saturation (BS) was calculated using:

$$\% \text{ BS} = \frac{\text{TEB x 100}}{\text{CEC}}$$

2.11 Dispersion Ratio

Dispersion ratio was analyzed by determining the soil silt and clay percentage in soil treated with calgon and also with water according to modified method of Nkidi-Kizza et al. (1984). Pipette method was used for silt and clay percentage determination. Dispersion ratio was expressed in percentage as;

$$\frac{\text{Water dispersed silt and clay (g)}}{\text{Calgon dispersed silt and clay (g)}} \text{ x } 100$$

High dispersion ratio implies greater soil erodibility.

2.12 Date Analysis

All analytical data were subjected to statistical studies; average and standard deviation were calculated according to Steel and Torrie (1980).

3. Result

3.1 Initial Soil Properties Before the Commencement of The Study

The result of the Igbariam soil showed that the soil is of sandy clay loam textural class and acidic with a pH of 5.1 and the electrical conductivity relatively high.

Table 1. Some properties of Igbariam soil

parameter		value
Clay%		28.9±0.2
Silt%		4.2± 0.6
Sand%		66.9 ± 0.4
Textural class		sandy clay loam
pH (H_2o)		5.1 ± 0.1
Electrical conductivity	μscm^{-1}	105 ± 5

3.2 Effect of Ageratum Sp On the Biomass Survival of Eudrilus Eugeniae and Irridodrilus sp

The result presented in Table 2 indicated that the rate of survival of earthworm in the composted ageratum was more on the *Eudrilus eugeniae* compared to *Irridodrilus sp*. Though the initial biomass of *Irridodrilus sp* indicated higher value but through the processes of incubation and culturing many of the *Irridodrilus sp* died leading to the loss of biomass value which resulted to zero survival.

Table 2. Effect of Ageratum sp on the biomass survival of Eudriluseugeniae and Irridodrilussp

Earthworm Specie	Biomass (g) Initial	Biomass (g) after incubation	Biomass loss g/earthworm	Survival
Eudrilus Eugenia	1.02 ± 0.59	0.72±0.25	0.27±0.14	66%
Irridodrilus sp	1.14±0.00	0.00±0.00	1.14±0.00 2	0%

3.3 Effect of Eudrilus Eugeniae and Irridodrilus Sp on Soil Properties

The clay + silt content result varied among the treatment (Table 3). Higher value (31.1%) was recorded in ageratum treated soil compared to the other treatments, the result variation indicated AG > CO > AE > AI. Apart from Ageratum that showed alkaline pH with a value of 9.15, other treatments showed acid reaction. Electrical conductivity, CEC osmotic pressure, exchange acidity was recorded highest in AE, followed by AI of which the result variation of the four parameters showed AE > AI > AG > CO. The net electrical charge indicated negative for all the treatments.

The result presented in Table 4 indicated base saturation (BS) value to be higher in AG relative to other treatments. AE recorded the highest value in soluble cation (Table 4) of which the percentage increase in value relative to AG and CO was 135.19% and 157.63% respectively. The recorded values for CEC and exchange acidity (EA) indicated AE and CO respectively to be higher relative to other treatments (Table 4).

Table 3. Effect of Eudriluseugeniae and Irridodrilussp on soil physicochemical properties

Earthworm Specie	pH (H_20)	Clay + silt Dispersion ratio (%)	Electrical conductivity uscm^{-1}	Osmotic pressure Kpa/atm	Net electrical charge
AE	5.13±0.05	9.3±3.7	270±22	9.849/0.0972	Negative
AI	5.50±0.16	5.2±0.7	237±25	8.645/0.0853	Negative
AG	9.15±0.05	31.1±2.2	115±5	4.195/0.0414	Negative
CO	5.10±10	19.2±0.9	105 ±5	3.830/0.0378	Negative

Ageratum + soil = AG; Ageratum + soil + *Eudrilus Eugeniae* = AE; Ageratum + soil + *Irridodrilus sp* = A1; Control soil = CO

Table 4. Effect of Eudrilus eugeniae and Irridodrilus sp on soil physicochemical properties

Earthworms Specie/soil Treatment	Cation exchange capacity(CEC) Meq/100g	Exchange acidity meq(0H)/100g	Base Saturation %	Dissolved (soluble) Cation meq/100g
AE	28.0± 7.0	5.63±0.67	79.89±2.39	0.675±0.054
AI	22.7±1.7	4.39±1.95	80.66±8.6	0.592±0.062
AG	19.3±1.7	2.15±0.35	88.84±1.81	0.287±0.012
CO	14.0±0.0	13.75±0.46	1.79±0.65	0.262±0.012

4. Discussion

From the result of the study, it was evidence that the two earthworms responded differently to the ageratum (pesticide) treated soil. At the course of the study it was observed that the two earthworms penetrated promptly within the treated soil litter after inoculation and produced typical surface casts that are always used to assess adaptability and proliferation. The activity and cast production of the worms continued for the following 5 weeks during the 12 weeks of incubation period, however, after the 5 weeks, period the activity of the worms declined that led to 67% survival recorded by *Eudriluus eugeniae* and 0% by *Irridodrilus* sp. thus indicating that *Eudriluseugeniae* has greater resistance to the ageratum. The surviving *Eudrilus eugeniae*, however lost weight to an average of 27% indicating that AG is seemly toxic to both earthworms. Ageratum has antioxidant property and various phytochemical contents (Nageivellema et al., 2004). This problem results in the death of *Irridodrilus sp* and loss of weight on the survived *Eudrilus eugeniae* and that was because *Eudrilus eugeniae* noted to be tolerant to disturbances and harsh culture situations than most other earthworms may not possibly adapt (Nweke 2017). More so, they are superficial soil layer leaf litter decomposer they do not move deep into the soil where these toxic substance may have accumulated the more.

Although the survival percentage of the two different earthworms in ageratum treated soil was poor, both earthworms ploughed the soil transforming it into a network of channels and burrows with water stable soil aggregates. Particularly is the bioremediation efficacy of both earthworms on soil physical properties as indicated by the clay + silt dispersion ratio, pig manure enhanced this property particularly with the worms. Clay + silt dispersion ratio is a good measure of erodibility and soil aggregate stability. The greater the index, the more dispersed the soil is that is the more erodible the soil will be. AG without earthworm inoculation exerted higher dispersion to the tune of 62% relative to the original soil, while both *Eudrilus eugeniae* and *Irridodrilus sp* inoculated ageratum treated soil addressed the AG dispersion effect thereby reduced soil dispersion ratio by 52% and 73% respectively of which *Irridodrilus sp* was efficient than *Eudrilus eugeniae*. In this regard AG produced alkalinisation effect by having a pH value of 9.15, this simple suggest that humus cementing agent in the treated soil must have been dissolved thereby releasing clay and silt primary particles as dispersed particles. It is noteworthy that both *Eudrilus eugeniae* and *Irridodrilus sp* reduced AG alkalinisation effect by bring the soil pH to 5.1 – 5.5 conducive for good aggregate stability as well as enhanced nutrient availability. Increased soil electrical conductivity and soluble cations recorded in the study with both earthworms is an evidence of greater mineralization and enhancement of biological activities induced by the earthworms. These observations are highly the enormous resourcefulness of *Eudrilus eugeniae* and *Irridodrilus sp* to promote soil conservation and soil productivity and erosion resistance, in this regard the role of both earthworms are crucial and indispensable. Earthworms enhance water intake and transmission through improvement of soil physical properties (Rombke et al., 2005; Sautter et al., 2006); their activities create favourable micro-environment for soil microbial activities composition and biomass (Hale et al., 2005, Jimens et al., 2006).

The enhancement of CEC, soluble cation and base saturation by the worms in AG treated soil showed the indispensable role of the two earthworms in mobilizing AG organic matter and nutrient elements of which pig manure played a vital role. *Eudrilus eugeniae* and *Irridodrilus sp* enhanced soluble cation (nutrient availability) for over two fold increase while 100% and 67% increase in CEC respectively was observed. The contribution of AG treated soil in this regard was however, far less with 9% and 38% increase in soluble cation level and in CEC respectively. The super achievement of *Eudrilus eugeniae* with regard to CEC and release of soluble cation indicated *Eudrilus eugeniae* greater efficacy relative to *Irridodrilus sp.* This is in line with the inherent capability of *Eudrilus eugeniae* as efficient bio-degraders and nutrient releasers to produce high quality vermicompost rich in colloidal humus and can thrive in organic residue within or outside the soil (Nweke 2013). Higher CEC and available cation in *Eudrilus eugeniae* worked soil suggested greater level of high quality organic colloid ion exchanger produced by *Eudrilus eugeniae* from AG biofertilizer, together with increased base saturation registered in AG and the two earthworms relative to the original soil confirm the tremendous boost to soil productivity by the earthworms and AG biofertilizer. Despite the contributions of AG it still proved toxic to the earthworms this constraint further need to be addressed in order to optimize AG bio-fertilizer / pesticide potential.

5. Conclusion

The findings of this study have shown that the contributions of the earthworms are indispensable to the successes of Ageratum (natural biopesticide) to promote sustainable high soil productivity and soil conservation. Earthworm's activity addresses AG dispersion effect and rendered the soil pH 5.1-5.5 about optimum for most nutrient availability, Though AG being a natural biopesticide was toxic to the worms by the virtue of their lost weight and survival rates proved good organic source for the management of soil CEC and soil erosion control. AG alone without earthworms may render the soil more erodible and too alkaline, but with earthworm inoculation it boosted the soil nutrient availability optimally. Thus AG needs to be modified in order to be optimized profitably and farmers are encouraged to under study this technology to discourage the use of chemical pesticides and fertilizers.

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